# Lake Enrichment Program: Juvenile Sockeye Unit Survey Guidelines

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# LAKE ENRICHMENT PROGRAM: JUVENILE SOCKEYE UNIT SURVEY GUIDELINES

by

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## ABSTRACT

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The Lake Enrichment Program (LEP) of the Fisheries Research Branch (FRB) and Salmon Enhancement Program (SEP) has a twin mandate to (a) utilize lake fertilization as a sockeye enhancement technique in British Columbia coastal lakes and (b) to conduct research to initially assess and finally optimize the cost effectiveness of the technique. The current Lake Enrichment Program is an organizational hybrid which must routinely integrate both private and public sector expertise in order to fulfill its mandate. In this report we outline the range of research, enhancement operations and stock management responsibilities of the Fish Ecology Unit of LEP as well as the public and private sector organizational links that are necessary to meet these responsibilities. Consideration of the benefits and costs of contracting-out the majority of our field site assessments indicates an urgent need for greater standardization and documentation of field-survey procedures. Guidelines to achieve this are identified with respect to contract fieldwork generally authorized by the juvenile sockeye ecology unit of LEP. Guidelines cover procedures to be followed in completing smolt surveys, littoral zone fish-population census, hydroacoustic and midwater-trawl surveys and zooplankton sampling.

## RESUME

Hyatt, K. D., D. Rutherford, T. Gjernes, P. Rankin and T. Cone. 1984. Lake Enrichment Program: Juvenile sockeye unit survey guidelines. Can. MS Rep. Fish. Aquat. Sci. 1796: 84 p.

Le Programme d'enrichissement de lacs (PEL), de la Direction de la recherche sur les pêches, et le Programme de mise en valeur des salmonidés (PMVS) ont un double mandat: a) utiliser la fertilisation lacustre comme technique de mise en valeur du saumon rouge dans les lacs côtiers de la Colombie-Britannique et b) réaliser des recherches en vue d'évaluer et de rentabiliser cette technique. Du point de vue de son organisation, le PEL est actuellement un hybride qui doit systématiquement faire appel aux connaissances techniques des secteurs public et privé afin de s'acquitter de son mandat. Le présent rapport décrit, d'une part, la gamme des recherches, les opérations de mise en valeur et les responsabilités en matière de gestion des stocks qui incombent à la Section de l'écologie piscicole du PEL ainsi que, d'autre part, les liens d'organisation que celui-ci doit maintenir entre les secteurs public et privé pour remplir ses responsabilités. L'examen des coûts et avantages liés à l'adjudication de la plupart des évaluations de sites expériementaux indique un besoin urgent de normaliser et de documenter davantage les méthodes de levé sur le terrain. À cet effet, on présente des lignes directrices pour le travail contractuel sur le terrain, généralement autorisé par la Section de l'écologie du saumon rouge juvénile du PEL. Ces lignes directrices portent sur les méthodes à suivre pour réaliser des levés de saumoneaux, le recensement des populations ichytyocoles de la zone littorale, des levés hydroacoustiques, des études à l'aide de chalut méso-pélagique et l'échantillonnage du zooplancton.

# INTRODUCTION

Between the years 1969 to 1975, investigators with the Fisheries Research Board of Canada conducted an experimental study at Great Central Lake, British Columbia to test the hypothesis that increasing the supply of inorganic nutrients in an ultraoligotrophic lake would increase production at succeeding trophic levels and would consequently serve as a useful technique to enhance the productivity of a stock of sockeye salmon. LeBrasseur et al. (1978) reported that during fertilized years mean summer primary production increased fivefold, zooplankton standing stock increased 9 times, the percentage survival from estimated potential egg deposition to juvenile sockeye increased 2.6 times, while mean stock size of adult sockeye increased from < 50,000 to > 360,000. Given the apparent 7-fold increase in Great Central Lake adult sockeye returns compared to pretreatment "historic" levels LeBrasseur et al. (1979) concluded that lake fertilization could serve as a highly cost effective technique to enhance sockeye salmon. Thus, when the Salmonid Enhancement Program (SEP) was launched in 1977 as a joint effort of the Federal and Province of British Columbia Governments, an expanded Lake Enrichment Program (LEP) was initiated as an experimental technique for the enhancement of sockeye salmon in a variety of B.C. coastal lakes. The Fisheries Research Branch (FRB) serves as the source of scientific and technical expertise with funding provided by SEP.

The primary long term goal of our program is to utilize lake fertilization wherever possible as a cost effective technique to maximize the production of sockeye salmon on the B.C. coast. Consequently we conduct research, in support of this long-term goal, to determine when, where, how often, how well and by what biological mechanisms lake enrichment works as a technique to enhance the production of natural stocks of sockeye salmon (Stockner and Hyatt 1984). The Lake Enrichment Program has a wide range of responsibilities for both operations and research activities associated with treatment and surveys up to twenty-five generally remote lakes dispersed along the entire length of the B.C. coast (Fig. 1). The logistics of carrying out our work are complex. Adding to this complexity was the decision by senior management early on in the evolution of Lake Enrichment as an FRB-SEP project to provide much of the expertise and manpower for operations and assessment activities in the field through the process of contracting-out to the private sector. Consequently the current Lake Enrichment Program is an organizational hybrid characterized by a unique set of advantages and disadvantages stemming from its private-sector public-sector makeup (see Hyatt 1984 for summary).

Certain advantages and disadvantages appear to form indivisible pairs characteristic of contracting-out as currently practised in the Pacific Region. For example contracting-out produces an advantage in that competitive bidding is a force favouring the cost-effective application of equipment and personnel to execute a piece of work. However, the accompanying disadvantage is that various forces, including competitive bidding, operate within the current contracting-out process to increase personnel turnover. Frequent turnover of personnel in turn tends to: (1) obscure the organizational and activity continuum which characterizes our program; (2) retard the acquisition of skills and suppress the development of new techniques for executing work where intervals required are longer than a year, (3) fragment the execution of

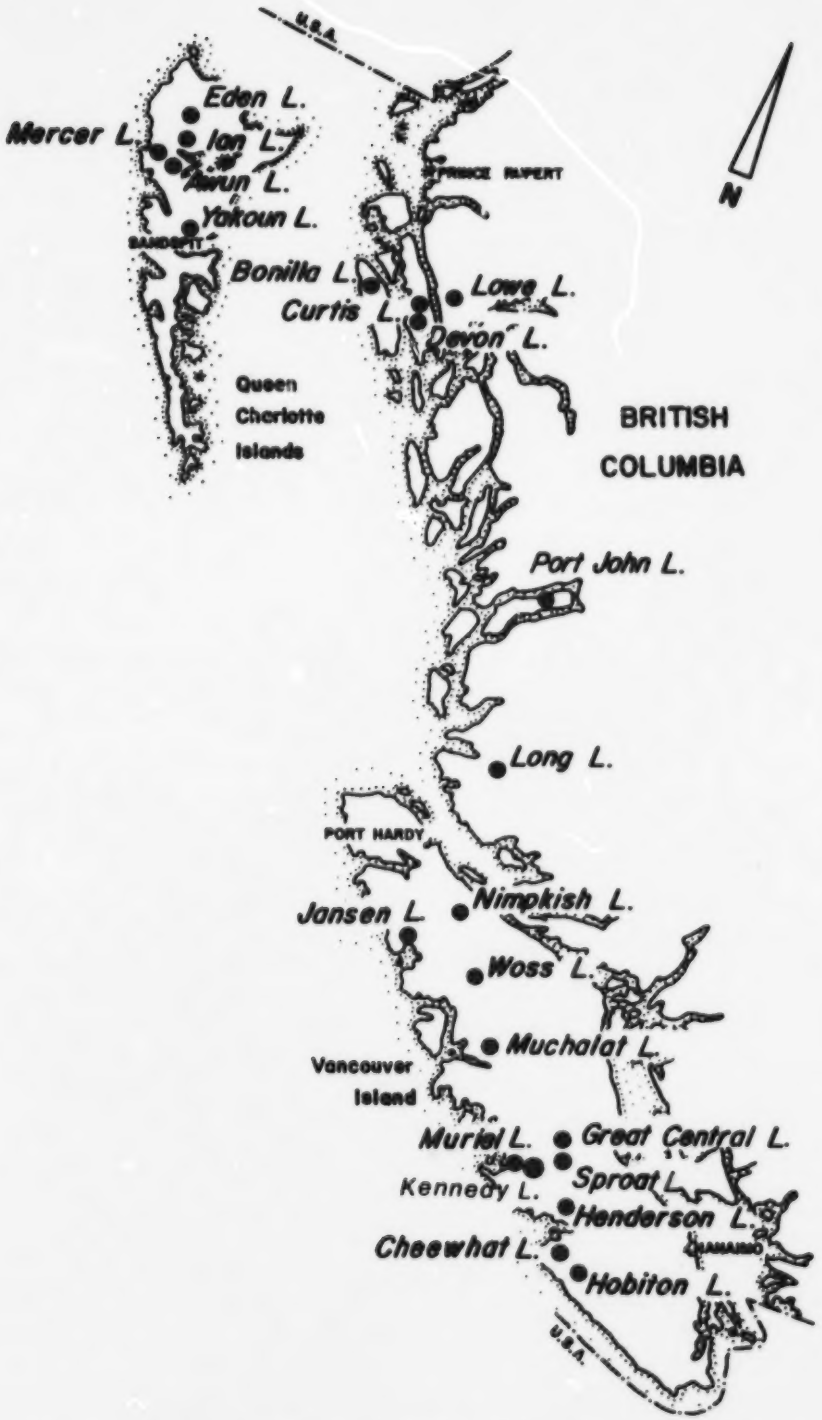



Fig. 1. Distribution of British Columbia coastal lakes currently under study by the Fish Ecology Unit.

work by disrupting adherence to highly standardized procedures, and (4) threaten the quality of data assembled and increase the difficulty of later interpretation. These disadvantages are particularly troublesome for operation and research activities which necessitate work involving multiyear intervals for completion.

The purpose of the present report is to overcome some of these disadvantages as they relate to a portion of the field work currently carried out by the Fish Ecology Subprogram of the Lake Enrichment Program. The first part of the report briefly describes the interaction among various LEP units,program activities and private sector contractors. It also contains an outline of the general scope of Fish Ecology Subprogram responsibilities. The second part of the report is a compendium of survey guidelines which cover most of the types of field sampling procedures currently required to complete work specified annually within juvenile sockeye ecology contracts.

## LAKE ENRICHMENT PROGRAM ORGANIZATION AND ACTIVITIES

The Lake Enrichment Program is organized into three subprograms. The Lake Treatment Subprogram deals with the operational end of controlled introductions of inorganic nutrients into coastal lakes. The Limnology Subprogram carries out both initial surveys required to rank lakes with respect to their desirability for treatment from a limnological perspective and long-term surveys to assess responses of water quality and lower trophic levels to controlled nutrient additions. The Fish Ecology Subprogram conducts surveys to rank lakes with respect to their desirability for treatment from a fisheries perspective and has a mandate to assess the impact of lake treatment on the zooplankton food resources of sockeye, on juvenile sockeye growth and survival and on production of adult sockeye.

The Fish Ecology Subprogram is organized into a series of units which interact with private sector contractors to provide information to respond to a wide range of research, enhancement-operations and stock management responsibilities (Table 1). The partitioning of activities among Fish Ecology Subprogram units and private sector companies (Fig. 2) results in considerable fragmentation of our work. To partially overcome this disadvantage the Fish Ecology Subprogram retains total responsibility for study design as well as for final analysis and reporting on research, operations and management issues. By contrast private-sector contracts focus principally on activities associated with study execution, data assembly, preliminary analysis and the production of interim reports. This arbitrary partitioning of activities requires close cooperation and effective communication to overcome the many inefficiencies that arise from the multilayered administrative controls over this private-sector, public-sector enterprise. In what follows we have developed a set of field survey guidelines for contract work authorized by the juvenile sockeye ecology unit of LEP. It is our hope that these guidelines will promote greater

Table 1. General scope of Fish Ecology Unit responsibilities.

| A. Research Issues | B. Enhancement Operations Issues | C. Stock Management Issues |
|---|---|---|
| Determinations of: | Determinations of: | Provision of: |
| 1. within-lake survival and sockeye smolt numbers. | 1. optimal carrying capacity of untreated and treated coastal lakes for sockeye. | 1. pre-season sockeye return forecasts to managers. |
| 2. within-lake growth of juvenile sockeye and smolt size. | 2. lake specific differences in sockeye carrying capacity and reasons for such differences. | 2. in-season information on stock return timing and composition. |
| 3. marine survival variations as % of smolts returning as adults. | 3. pre-treatment conditions that preclude the use of lake fertilization as an effective enhancement technique (e.g. chronic fry-recruitment failure). | 3. stock-specific estimates of optimal escapement based on observation of escapement size and number of pre-smolts produced. |
| 4. procedures and data concerning growth on age and biomass at return of adults. | | 4. effects of freshwater escapement estimate accuracy. |

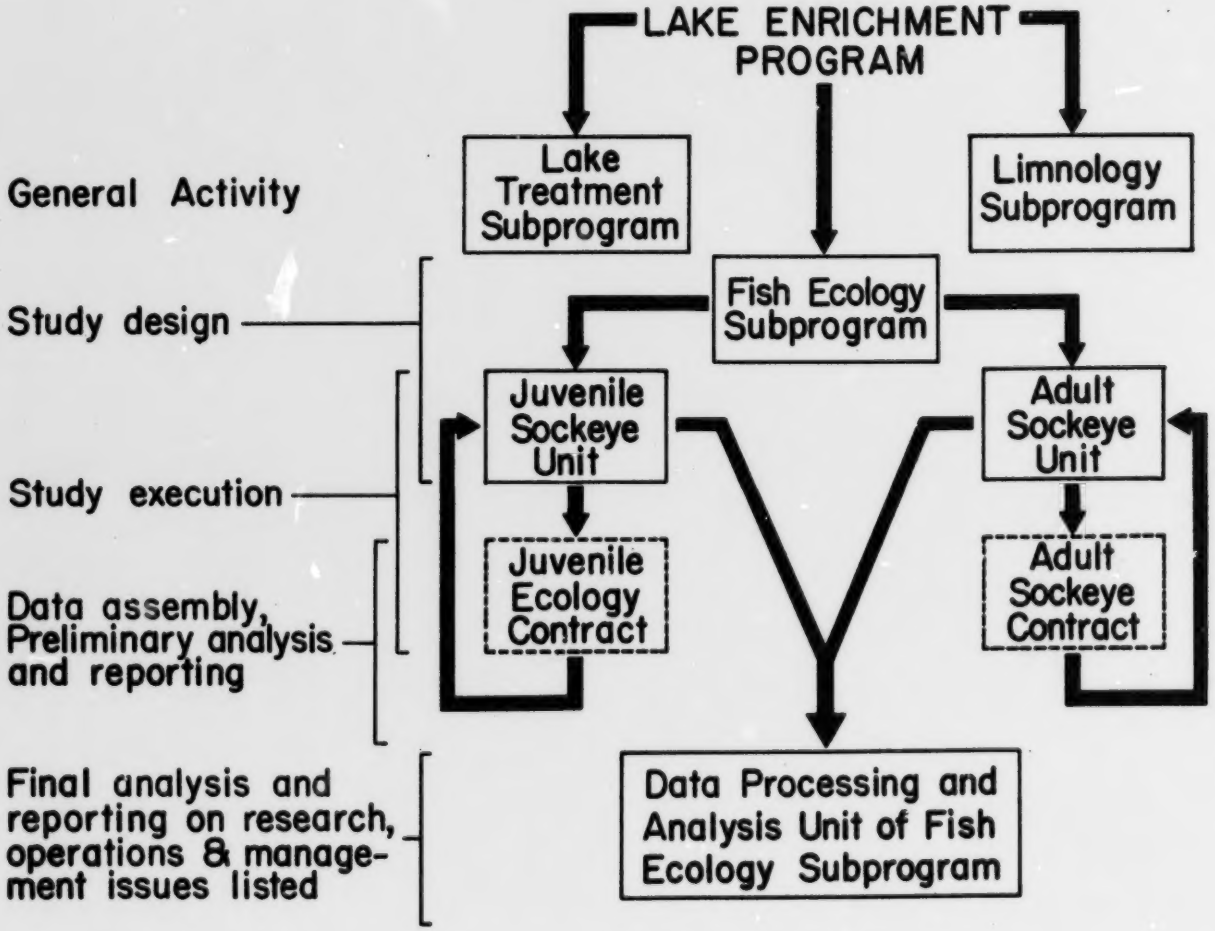



Fig. 2. An outline of organizational links and activities shared among the Fish Ecology Subprogram of LEP and private-sector contractors.

standardization of survey procedures and reduce the number of surveys compromised due to technical difficulties. The guidelines should also facilitate a smooth transition from sample collection to sample processing and final entry into an existing multiyear, electronic data-base.

Guidelines presented in this report are intended to be used principally by juvenile-ecology contractors and in-house personnel. The report is not intended nor suitable for use as a training manual for implementation of sampling routines by inexperienced field crews but rather as a supplemental reference once general procedures have been mastered. Sampling procedures are described in four sections which cover (A) sockeye smolt sampling, (B) stickleback trapping, (C) hydroacoustic and trawl surveys and finally, (D) zooplankton sampling.

## SOCKEYE SMOLT SAMPLING

Age-specific size of sockeye smolts at the initiation of seaward migration serves as an index used to detect differences in sockeye growth between treated and untreated years within the coastal study lakes. Hyatt and Stockner (1985) should be consulted regarding interim results associated with smolt sampling activities to the spring of 1982; however, it is clear that continued sampling will be necessary to fill in gaps in our knowledge regarding factors controlling the size of sockeye smolts produced in untreated lakes and years if we are to properly assess the scope for lake fertilization to generally alter smolt sizes in nutrient poor coastal lakes. Sampling procedures to be followed are outlined below with respect to: (1) seasonal timing and level of effort, (2) sample-site selection and gear deployment, and (3) sample handling and documentation.

### SEASONAL TIMING AND EFFORT

It is desirable to obtain smolt samples that are representative of the lakewide population. Past experience suggests that samples obtained very early in an annual smolt run will be biased towards larger smolts-at-age and disproportionately represented by two-year-old sockeye (Foerster 1968, Authors unpublished data). Similarly samples obtained towards the tail end of the smolt run in early summer will be biased towards larger fish since enough time will have elapsed for fish to have grown appreciably since the early spring. Smolt samples are more likely to be representative of the lakewide population if they are taken during the short interval when the majority of juvenile sockeye are moving seaward. A further advantage is that less sampling effort is generally required at these times to obtain large numbers of migrating fish in good condition.

The spring migration patterns for sockeye smolts leaving B.C. outer coast lakes varies among populations and sites (Fig. 3); however, some generalizations can be made. The peak weekly migration occurs during the week ending May 7 (Fig. 3d) or more commonly May 14. For most populations more

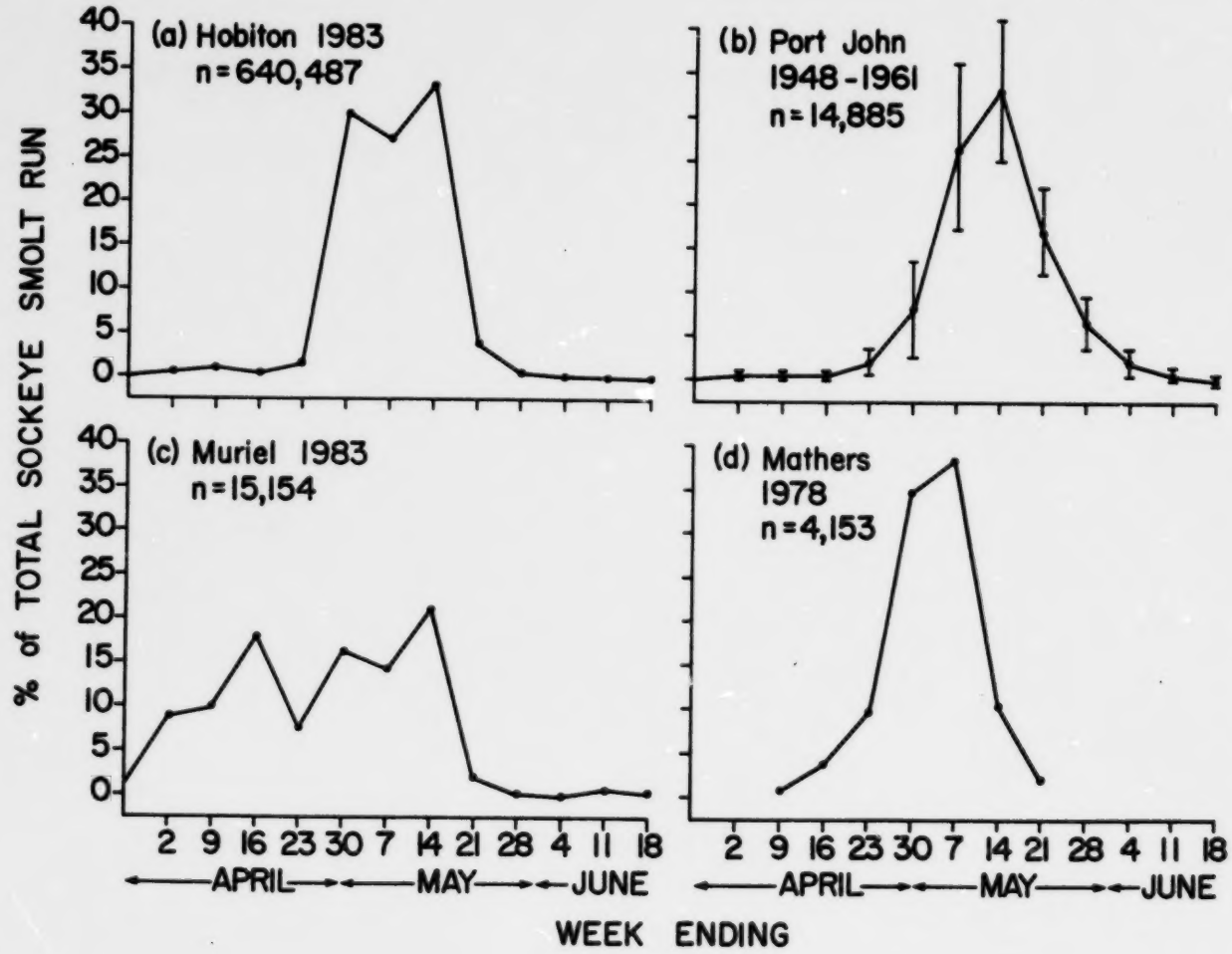



Fig. 3. A comparison of weekly migration patterns for sockeye salmon (O. nerka) smolts of four selected outer-coast lakes. Observations are based upon fence counts at Hobiton, Muriel and Port John lakes (authors unpublished data) and trap sets at Mathers Lake (Shepherd 1978). Vertical bars are 95% confidence intervals of the 13 year means at Port John Lake.

than 75% of the migrants move seaward during a three week interval between April 30 and May 21. The migration pattern of sockeye smolts leaving Muriel Lake (Fig. 3c) is an exception to this since over 50% of the smolts have been observed to leave by April 30. This early migration may be related to the fact that sockeye smolts leaving Muriel Lake in the spring of 1983 were predominantly two-year-olds which tend to migrate relatively early. Seasonal smolt-migration patterns are consistent enough to recommend some general guidelines for sample acquisition from coastal lakes lacking weirs.

(i) Smolt sampling should be scheduled in a given year so that spot surveys are completed during the 4-week interval beginning April 16 and ending May 14.

(ii) Whenever possible, schedules should be set so that all lakes receive at least two sampling trips during the interval between April 23 and May 14. If the logistics of sampling will not permit this, priority-scheduling to sample within this interval should be assigned to lakes in which fall census work has indicated the migrant population is likely to be small. Very small lakes (< 300 ha) and large lakes containing low-density sockeye populations (e.g. Ian Lake in the Charlottes) are examples of the latter. Sufficient numbers of smolts can generally be obtained on sampling trips to lakes containing large populations of juvenile sockeye even when sampling trips are displaced from peak migration intervals by a week or two.

SITE SELECTION, GEAR DEPLOYMENT AND DAILY TIMING

(i) Smolt sampling is conducted by deploying a variable mesh "trawl" net in the major outlet streams of each lake sampled. The net normally used is 2 m x 2m x 7.5 m in width, depth, and length respectively. It is composed of a graded series of meshes from mouth (5.0 cm stretch mesh) to codend (1.3 cm knotless nylon). Two of these nets should be taken on all smolt surveys.

(ii) It is important that the site selected for the net be in a current regime strong enough to prevent the escape of fish once they are inside the net but not so strong as to vigorously agitate captured fish. The latter event will produce excessive loss of scales from fish and will subsequently hinder age determination later in the laboratory.

(iii) Due to differences in topography and hydraulics among sites, various configurations of net frames, cables and supplementary wings should be considered in setting nets to obtain smolts (Fig. 4). The addition of supplementary wings to gear (Fig. 4b) should be considered whenever: stream flow directing fish into trapping gear is low, stream cross-sections are wide, presmolt population size is known to be low and large volumes of water must be sampled in order to increase the probability of obtaining a sample of sufficient size (i.e. > 100 sockeye smolts.trip$^{-1}$).

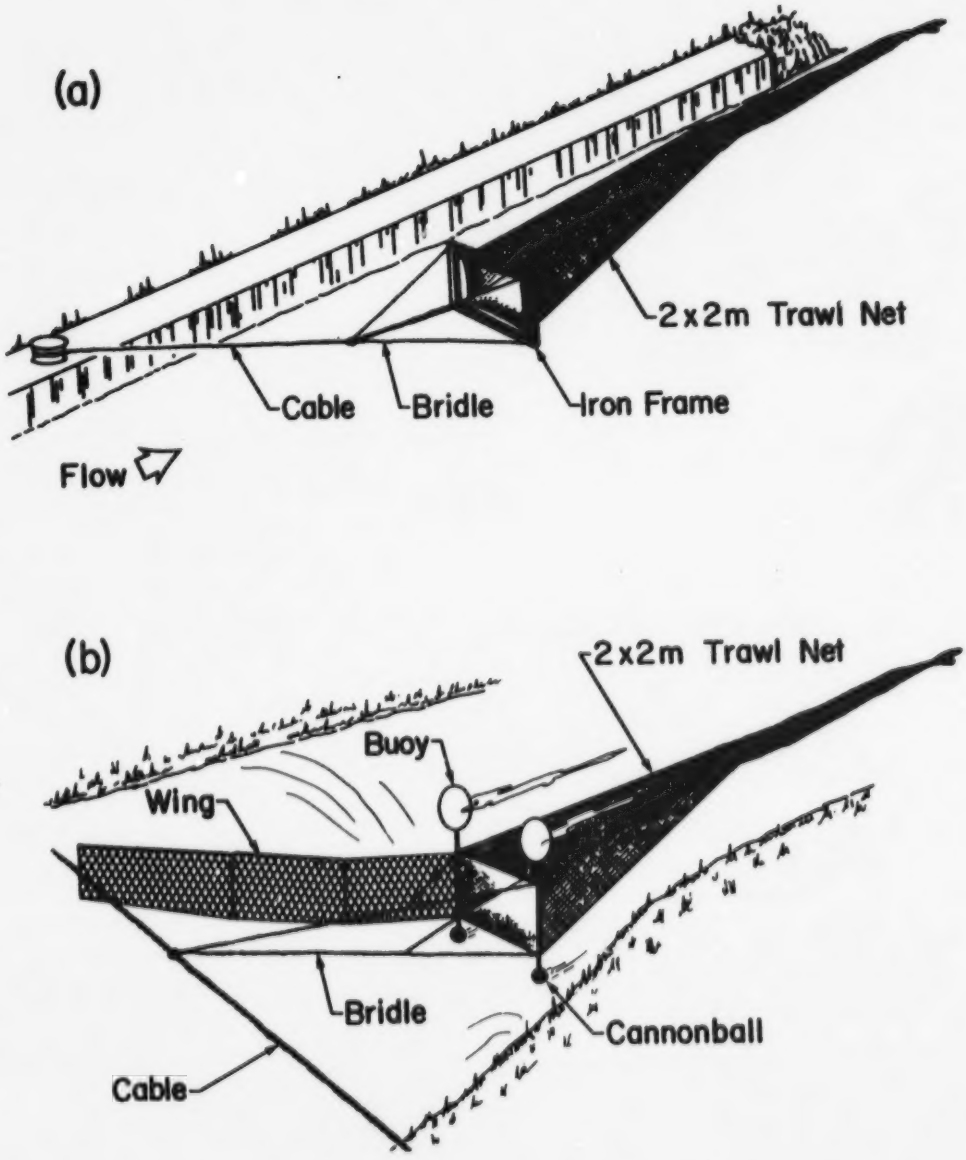



Fig. 4. Alternatives for smolt-net set configurations in large (4a) and small (4b) coastal streams.

(iv) Sockeye smolts generally migrate at night, consequently smolt traps should be set approximately one hour before civil twilight and operated for a 3-4 hour period to intercept the maximum number of fish.

(v) If the number of sockeye smolts captured during this initial 3-4 hour interval is relatively small (i.e. < 100) the net should be left unattended overnight and lifted by 0800 hours the following morning to increase the chances of obtaining an adequate sample.

(vi) On each trip to a given lake the goal should be to acquire a sample of no less than 100 and no more than 400 sockeye smolts unless otherwise advised.

(vii) Continuation of sampling for additional nights (to a maximum of 3 unless otherwise specified) at a given site will be necessary if less than 100 but more than 25 sockeye smolts are obtained during the first night of trapping.

## SAMPLE HANDLING AND DOCUMENTATION

It is important to remember that all fish samples obtained for the Fish Ecology Unit of LEP provide a number of pieces of information, so it is imperative that they be handled properly. Rough handling and either improper preservation or labelling can result in a sample that provides little or no useable information. Sockeye samples especially are very intolerant of mishandling. Guidelines for handling are as follows:

(i) During the initial 3-4 hour interval of a set, the net should be emptied of fish every 15-20 min depending on the number caught and the likelihood of descaling due to high-water velocities. Frequent removal of specimens from the net codend will improve the quality of the smolts sampled.

(ii) Chinook (*Oncorhynchus tschawytscha*) smolts, coho smolts (*O. kisutch*), threespine sticklebacks (*G. aculeatus*) and lamprey (various species) caught incidental to sockeye smolts should be retained in addition to sockeye for later processing in the laboratory.

(iii) If fish are to be counted, try not to handle them more than necessary to prevent descaling.

(iv) All fish retained during smolt sampling should be killed in a strong solution (100 to 1 of concentrate) of 2-phenoxyethanol (fish anaesthetic) or a 95% ethanol solution. Immediately after killing, fish should be transferred for preservation into a 10% buffered formalin solution. When fish are placed in jars, keep the formalin to fish ratio about the same (i.e. 1/2 jar of fish topped with formalin). Be generous with the formalin! Always use 10% formalin (solution of 1 liter of 37% formaldehyde and 4 tablespoons of borax diluted with water to 10 liters).

(v) Labels placed within each sample jar should indicate the lake name, date of survey, start and stop time for a net-set, number caught, names of collectors whether all of the catch from this smolt-sampling site and date is in one or more containers.

(vi) Field notes should include: (a) a general description of the trapping site and its map location, (b) comments on gear type or configuration, (c) general comments on the magnitude and timing of the smolt runs observed over the sampling period, (d) a record of all fish caught by species according to trapping interval, (e) a record of prevailing environmental conditions relevant to migration activities of the smolts including: water temperature, water clarity, discharge level (e.g. stream flow normal, in flood, etc. . . .), recent rainfall, % cloud cover, phase of moon, presence of potential predators such as seals, otters or aggregations of piscivorous fish.

Finally, Hyatt and Stockner (1985) noted that uncontrolled variations in sample acquisition, sample handling and processing procedures have likely contributed to the relatively large amount of unexplained variation in size of sockeye smolts produced among lakes and years. Accordingly, continuous effort must be applied to maintain sampling standards at all steps leading to the creation of our smolt-size data base. Additional observations are also required concerning the reliability of the sampling procedures described above in obtaining representative samples of sockeye smolts and future sampling crews are encouraged to participate in providing such observations as field opportunities permit.

## STICKLEBACK TRAPPING IN LITTORAL ZONE HABITATS

All of the lakes that we currently study on the B.C. outer coast contain populations of threespine sticklebacks (Gasterosteus aculeatus) in addition to juvenile sockeye. In at least seven of the coastal lakes sticklebacks are abundant in the offshore waters during most seasons of the year and represent the most important potential competitors of juvenile sockeye. Consequently, we routinely sample sticklebacks along with juvenile sockeye through hydroacoustic and midwater trawling techniques (see later sections) to; (1) assess their relative abundance and potential for competition with juvenile sockeye; and (2) to assess whether lake-treatment affects their population ecology in ways that are detrimental to sockeye.

Since all G. aculeatus populations breed in the littoral zones of the coastal lakes between early spring and late summer we also frequently request that Gee-type, minnow-trap-sets be used in nearshore waters to obtain samples of breeding adults and occasionally to index their abundance. Data obtained on animals contained in such samples may allow us to identify life-history traits (e.g. population age-structure, fecundity, size-at-first maturity, length of breeding season, etc.) which apparently enable some populations of G. aculeatus, but not others, to exhibit rapid numerical responses to lake treatment.

Stickleback trapping has not yet evolved into a rigorously standardized procedure for estimating relative abundance and many uncertainties remain as to the best way in which to obtain samples that will be representative of the lakewide population. However, the following guidelines concerning (1) sample-site selection, (2) trap-deployment, and (3) sample handling and documentation are intended to reduce the uncertainties regarding the contribution of uncontrolled trapping procedures to various types of trap-sample data.

## SAMPLE-SITE SELECTION

During the summer breeding season, the distribution of G. aculeatus in the littoral zone of coastal lakes is patchy. Consequently, the following criteria should be followed in selecting areas for trap deployment.

1. Select areas that have
   - (i) extensive shallows (< 2 m deep) and gradually sloping bottoms.
   - (ii) structural features such as aquatic macrophytes or submerged logs and brush that may serve as cover.
   - (iii) rock cobble to gravel or mud substrates.
2. Avoid areas that are
   - (i) open and totally devoid of submerged cover.
   - (ii) characterized by substrates composed of very clean sand, clean rock-cobble or heavy accumulations of bark and leaf-litter.
   - (iii) exposed to wave action and exhibiting high turbidity.
3. Small embayments with shallow water, ample cover, gravel to mud substrates and protection from wave action are close to ideal. Sites should be marked as precisely as possible on bathymetric maps and should be readily identifiable on subsequent surveys, weeks to months later. Where possible the same sites should be used for trap-sampling on all surveys. In small lakes (< 1000 ha) identification of two standard sites for trapping will likely be sufficient. However, in large lakes (> 1000 ha) 3-5 trap sites should be selected if possible.

## TRAP DEPLOYMENT

(i) A single trap-set at a site will consist of a cluster of 10 traps spaced individually no closer than 2 m and no further than 50 m apart.

(ii) Place the long axis of each trap parallel to the shoreline or to whatever the closest cover elements are.

(iii) Place traps near the outer margin of weed-beds or concentrations of submerged brush rather than in or under structural elements which might impede entry of fish.

(iv) Do not bait traps.

(v) The depth at which traps are set should be precisely controlled since littoral-zone populations of G. aculeatus generally exhibit dramatic reductions in abundance with increasing water depth (Fig. 5). Accordingly, control trap sets by placing 5 traps at depths between .25 and .50 m and 5 traps at 1.0-1.5 m. If you are uncertain about the depth of a set, use a staff gauge to measure it. Exceptions to these controls on trap-set depth may occur in situations where recent lake-level increases "move" such depths up into what is clearly the shoreline vegetation zone. When these conditions are encountered, trap sets should be done at the shallowest practical depth without necessitating trap placement in a zone that is normally terrestrial. Note of this exceptional condition should be included in the field record of trap-set results.

(vi) Inshore populations of sticklebacks are primarily diurnally active such that little or no catch will be acquired during strictly nocturnal trapping intervals (Table 2). We wish to examine differences in catch per unit effort among various survey lakes, consequently, quantitative trap-sets should be allowed to fish for 5 hours of daylight. We do not have much information on diurnal variability in trap-set efficiency, therefore, it is desirable to complete 5-hour quantitative trap-sets within the interval from mid-day to early evening. Scheduling of surveys on some lakes may require completion of a 5-hour quantitative trap-set in the morning; however, avoid these whenever possible.

(vii) After recording and processing the catch from a 5-hour quantitative trap-set, permit traps to fish overnight and into the next day for additional qualitative sampling if the catch of G. aculeatus from the quantitative set is less than 100 fish for a given trip.

## PRELIMINARY PROCESSING AND DOCUMENTATION OF TRAP SAMPLES

1. Assign a station number (e.g. G-1, G-2) to each trap-set site selected for a given lake and make certain that these station numbers are indicated on field-site maps.

2. Provide an initial general description of each trap-set site. This should include:

   (i) a slope measurement = distance from the 2-m depth contour to the shoreline (in m) divided by 2;

Table 2. Total catch of G. aculeatus in replicated two-hour, trap-sets consisting of a single Gee-trap set at each of six depths (.5, 1.0, 1.5, 2.0, 3.0 and 4.0 m) during diurnal and nocturnal intervals on July 17-18, 1975 at Marion Lake, B.C.

| Diurnal sets | | Nocturnal sets | |
|---|---|---|---|
| Time | Catch | Time | Catch |
| 1330-1530 | 37 | 2100-2300 | 15 |
| | 43 | | 1 |
| 1600-1800 | 63 | 2130-2330 | 2 |
| | 125 | | 0 |
| 1900-2100 | 98 | 2330-0130 | 1 |
| | 48 | | 0 |
| Total | 414 | | 19 |

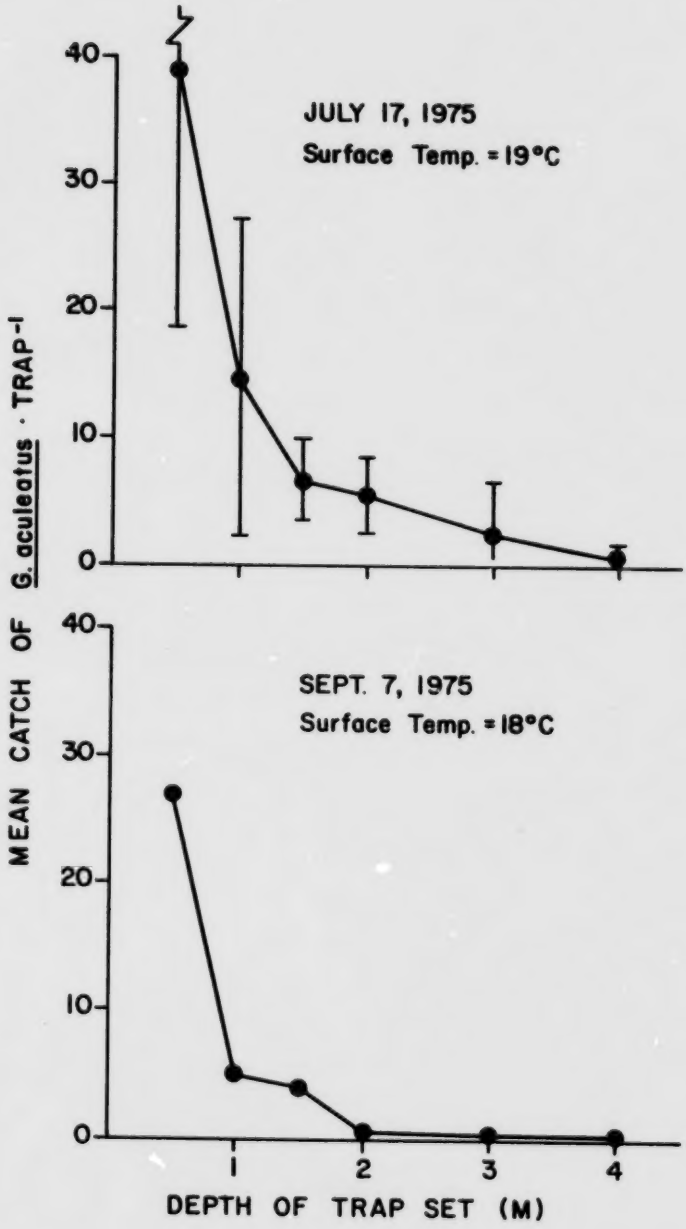



Fig. 5. The relationship between trap-set depth and catch . $trap^{-1}$ of threespine sticklebacks on two dates in Marion Lake, B.C. Vertical bars are 95% confidence intervals (K. Hyatt unpublished data).

(ii) a description of cover elements in which aquatic macrophytes, submerged brush or boulders are ranked as very abundant, sparse or absent;

(iii) substrate composition classed as cobble with boulders, cobble, gravel, open mud, mud with litter or sand.

Since the same trap sites are generally used on subsequent trips, follow-up descriptions will only be required with respect to conditions that have changed (e.g. aquatic vegetation may change from absent to very abundant at a site as the seasons change; shoreline flooding may require that trap sites be repositioned to maintain control on depth of set between trips).

3. Field notes should contain a record of the lake name, trap site number, date of survey, field crew personnel, trap-set depths, start and stop times for sets and set distances from shore.

4. Trap catches will generally be dominated by G. aculeatus; however, significant numbers of species such as coho salmon (Oncorhynchus kisutch), prickly sculpin (Cottus asper), peamouth chub (Mylocheilus caurinus) or salamanders (Ambystoma sp., Taricha sp.) may be acquired. Process catches as follows:

(i) enumerate and record all animals caught by species, by individual trap;

(ii) identify trap records at a given set site according to depth interval;

(iii) save only salmonids and sticklebacks for return to the laboratory unless otherwise directed;

(iv) the contents of each trap should be enumerated and recorded separately; however, the contents of all 10 traps from a given trap-site may be preserved together in one or more containers;

(v) trap-samples are to be preserved in 50% alcohol for 1 week and then transferred to 70% ethanol since sticklebacks must be aged from otoliths and formalin preservation makes otoliths unreadable (note the departure from the normal practice of preserving smolt samples or trawl catches in 10% formalin). It is especially important not to overload jars with fish to be preserved in ethanol! Be very generous with the alcohol; there should be the same volume if not more of alcohol than fish;

(vi) labels placed within jars should indicate the lake name, trap-site number, date of survey, and whether all catch for this site is in one or more containers.

## HYDROACOUSTIC AND TRAWL SURVEYS

### Background

The Fish Ecology Unit of LEP has carried out annual fish population census activities since 1977 at 6 to 22 B.C. coastal lakes. Field population estimates in the limnetic zone of each lake have been obtained through the application of hydroacoustic sampling techniques and complementary sampling with midwater trawl gear. For those not familiar with concepts behind the use of these techniques we highly recommend one or more readings of the review article by Thorne (1983).

Population census activities carried out by us since 1977 have relied principally on a Furuno, FM-22, 200 kHz sounder with 100 watts of power output. The sounder is maintained at a constant pulse width of 1.0 ms on all surveys and gain settings are standardized at 5 steps above the lowest setting at which sockeye can be detected to accommodate a range of target strengths (see Thorne 1983). The FM-22 is equipped with a time varied gain (TVG) circuit which controls for spreading and attenuation losses of the acoustic signal with distance. The transducer is a circular piston-type mounted on a hydroplane and is lashed into position alongside a 4 m long inflatable boat. This positioning allows depth strata greater than 2 m below the lake surface to be insonified. The effective beam width of the FM-22 has been estimated to be 8° by measuring the relationship between the depth of a standard target (tournament quality ping-pong balls) and the distance from the acoustic axis at which a target, equivalent in strength to a juvenile sockeye, can be detected.

The number of cross-lake transects completed on a survey is generally based on lake size and basin complexity such that the total lineal distance sounded on transects is roughly proportional to lake area and each basin of a lake is represented by at least one acoustic transect. Data from which population estimates are made, are restricted to the interval from midsummer to late winter. This is because seasonal changes in concentration in near-surface waters may make juvenile sockeye unavailable to the sounder. Acoustic surveys are conducted at night and at intervals of several weeks to several months for a given lake. Adherence to specified transect lengths and locations both within and between trips must be assured. This can be accomplished by marking the start and end points of transects with battery operated flashing lights at known shoreline locations during the day.

Echograms from a survey are divided into a maximum of 12 depth strata with intervals increasing with depth for visual counting. Targets are counted in each stratum. Due to the narrow beam width, short pulse length and relatively short range to targets on our surveys, target densities are only rarely high enough to produce a problem of coincidental counts for a stratum, consequently, unlike Barraclough and Robinson (1972) we generally do not have to resort to trawl catch data to estimate the numbers of fish present within a given depth stratum. The 2-3 m depth interval just below the lake surface is an exception to this since it is not insonified. The volume of water sampled in a stratum varies due to both the conical shape of the acoustic beam (larger volumes are insonified at greater depths) and the variation in transect length at depth produced by bathymetric patterns unique to each transect. Therefore

raw counts are adjusted to equivalent counts per unit volume. Mean and 95% confidence intervals of abundance estimates are based on the adjusted counts for a given depth stratum from the multiple acoustic transects completed for each lake. The estimate of mean abundance for a given lake and date is then simply the sum of the mean abundance estimates across all depth strata. To facilitate between-lake comparisons, abundance estimates are expressed as fish.ha$^{-1}$.

## ECHO-SOUNDING: PRACTICAL GUIDELINES

The echo-sounding portion of a survey is used to determine total fish abundance. The soundings may also be used to determine bathymetric contours in shallow lakes so it is important that while sounding transects a constant speed be maintained. The bottom contours of the lake will appear distorted on the sounder tracings if a constant speed is not maintained. Acoustic transect locations are normally established by the Scientific Authority (see Appendix 2). The transects must be distributed uniformly throughout the lake so all regions of the lake are equally represented. Once transect locations are established for a particular lake they must be maintained to eliminate the possibility of population variance between surveys being attributed to a change in transect location and sampling effort. When establishing transect locations it is also necessary to select land forms or points of land that can be easily recognized by the survey crew while on the lake. When sounding along transect lines the guidelines listed below should be followed.

(i) Accurately record transect number, start time, finish time, transect direction, sounder gain and depth scale setting.

(ii) Mark on sounder paper the start and finish point of the transect. The Simrad EYM has a built in marker which can be activated by pushing the button on the face of the echo-sounder. The Furuno FM22 does not have a marker but the transects can be separated by turning the "white line" on momentarily.

(iii) Record the readings off the distance log and place it in the water at the start of the transect. Upon completion of the transect remove the distance log and record the reading.

(iv) Select the shallowest echo-sounder scale that will record the majority of targets. For example, if most of the targets are present above 50 m, use the 0-50 m scale. If the majority of targets are present below 50 m, use the 0-100 m scale. See Fig. 6a for example of incorrect scale use.

(v) Ignore the presence of a false bottom (Fig. 6b) unless it interferes with the fish targets. If the false bottom does cause interference switch to the next deepest scale maintaining insonification of the surface stratum. For example if using the 0-60 m scale on the Simrad EYM switch to the 0-120 m scale not the 40-100 m scale. Occasionally check the shallower scale; if no interference is present then use the shallower scale.

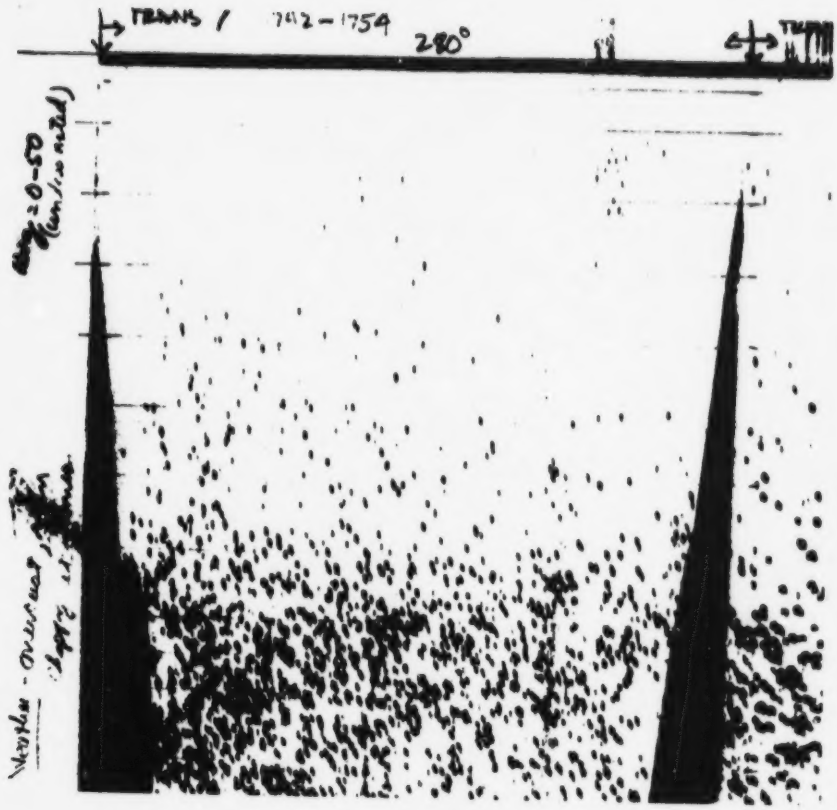



Fig. 6a. Reproduction of an echogram for which the incorrect depth-scale has been used. See text for details.

Fig. 6b. Reproduction of an echogram showing the presence of a false bottom.

(vi) On each survey check for target strength. This can be done by selecting an area on the lake in which targets are present, stop the boat, then turn the gain setting down and record the setting at which the targets are last detected.

(vii) Continually check the echo-sounding trace for target legibility. If targets do not appear "normal" refer to the echo-sounder trouble shooting guidelines and correct the problem before continuing on with the survey.

ECHO-SOUNDER TROUBLE SHOOTING

Some of the echo-sounder breakdowns which have occurred in the field have resulted in aborted surveys. Many of these breakdowns may be repaired in the field and the survey completed. On average, an aborted survey in a remote lake costs the program approximately $800, so it is essential that such failures are avoided as much as possible through proper maintenance of the sounder and trouble-shooting techniques. Outlined below is a field-oriented, trouble-shooting guide for both the Simrad EYM and Furuno FM22 echo-sounders.

Moisture in the echo-sounder is responsible for many incidents of sounder malfunction. The echo-sounders are not waterproof; therefore, keep them covered from rain and water spray. Water within the echo-sounder can create a multitude of problems ranging from the sounder not working at all to poor reproduction of targets on paper charts. If the sounder is wet take it to a dry or covered area and dry the collector and printer stylus, recording belt, collecting plate and paper. This will rectify most of the problems created by water within the sounder. When working on the sounder be sure it is turned off. The T.V.G. circuit in the Furuno FM22 can be blown by not following this precaution.

If the sounder is not wet and does not appear to be working properly consult the following guidelines.

(a) Recorder not working

The causes of this problem may be: wrong connection of the power source, low source voltage, blown fuse.

Remedy:

(i) check battery connections for correct polarity;

(ii) check battery charge;

(iii) check for possible short circuit caused by water, foreign object or crossed wires;

(vi) check if fuse has correct rating;

(v) replace fuse.

(b) Motor running but not recording

The cause of this problem may be a poor contact between the recording or collector stylus and the paper chart or collector rail respectively.

Remedy:

(i) Replace worn recorder or collector stylus.

(ii) If stylus is knocked off the belt by hand or jacket sleeve the stylus may end up in the bottom of the echo-sounder. To retrieve the stylus disconnect power supply and invert the sounder. The stylus should fall free. Reconnect stylus to the recording belt. See Fig. 7 for correct placement of stylus.

(iii) The paper contact nib (see Fig. 7) may be covered in "soot" which prevents adequate conductivity. Make sure this nib is cleaned <u>each time</u> a new roll of paper is used.

(c) Targets and/or sounder tracing does not appear "normal" - (see Fig. 8)

The causes of this problem are: transducer not riding correctly in water, sounder paper not loaded correctly or faulty stylus.

Remedy:

(i) Check for proper transducer positioning in water.

(ii) Check for correct tension and loading of sounder paper.

(iii) Check and clean paper contact nib. (Fig. 7).

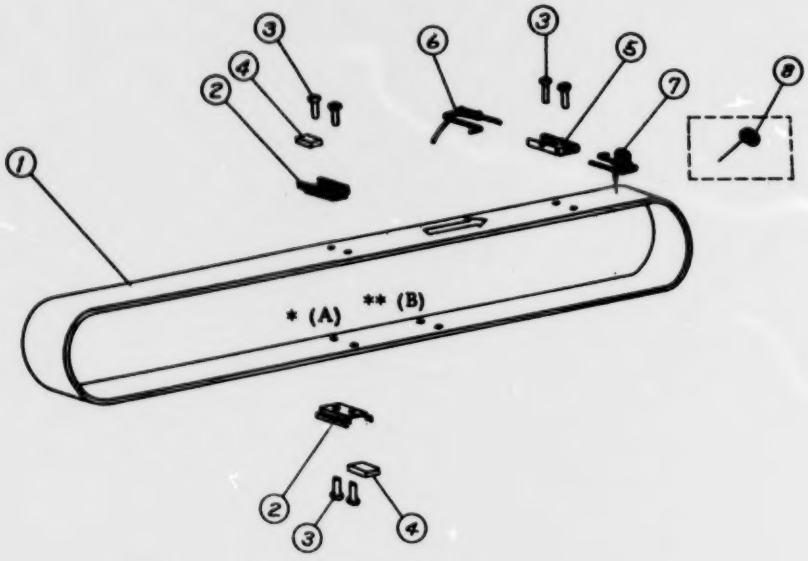
(iv) Replace faulty stylus.

(d) Heavy background "noise" which masks targets on paper (see Fig. 9a).

The causes of this problem are: incorrect placement of echo-sounder and power source, induction from other electrical or mechanical equipment on board. Under normal operating conditions some noise will appear very slightly at maximum gain setting.

Remedy:

(i) Place power source as far apart as possible from the transducer cable. The power cable should not be parallel to transducer cable, since this will result in mutual induction between both cables which can produce noise.




Recording belt

| No. | Part name |
|---|---|
| 1 | recording belt |
| 2 | magnet holder |
| 3 | eyelet |
| 4 | magnet |
| 5 | stylus holder |
| 6 | collector stylus |
| 7 | recording stylus |
| 8 | stylus nib |

Note: * Place magnet at position (A) for meter range.
** Place magnet at position (B) for fathom range.

Fig. 7. Correct position of recording stylus with respect to other parts of belt-drive on the Furuno FM-22 echo-sounder.

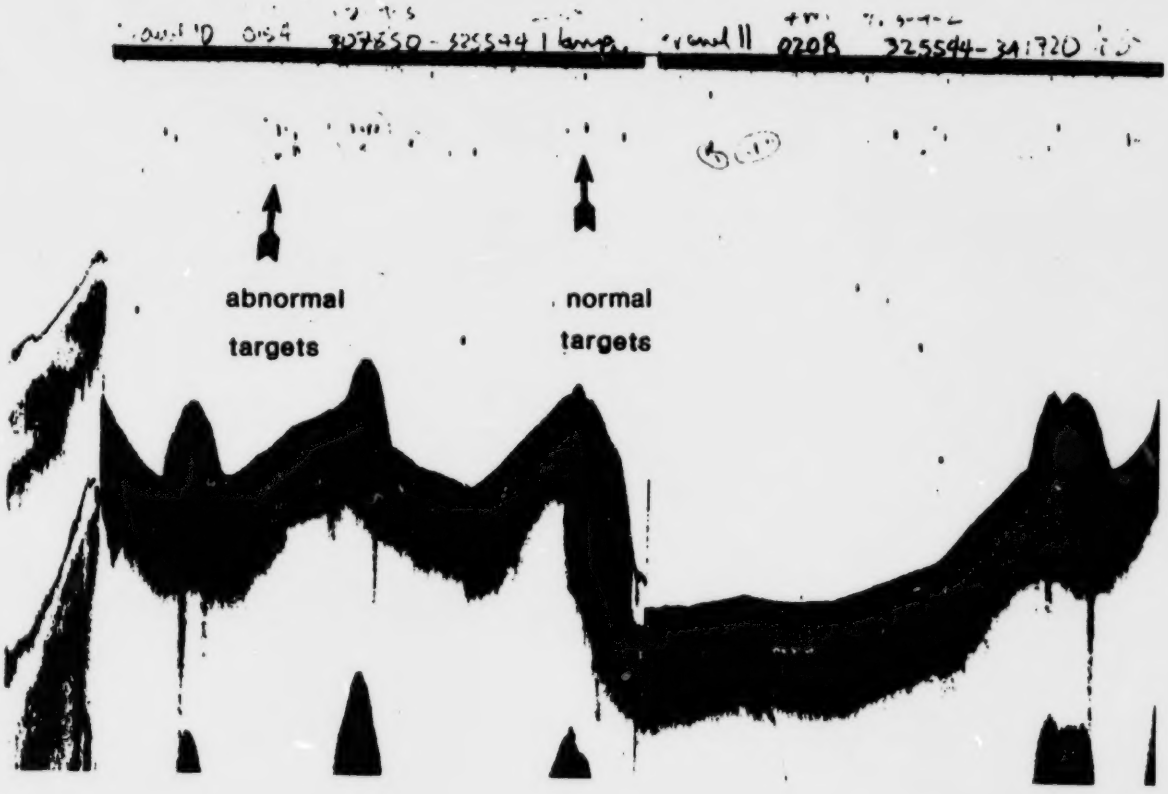



Fig. 8a. Reproduction of an echogram in which target recordings are abnormal due to improper stylus seating.

Fig. 8b. Reproduction of an echogram produced while experiencing chart-drive problems.

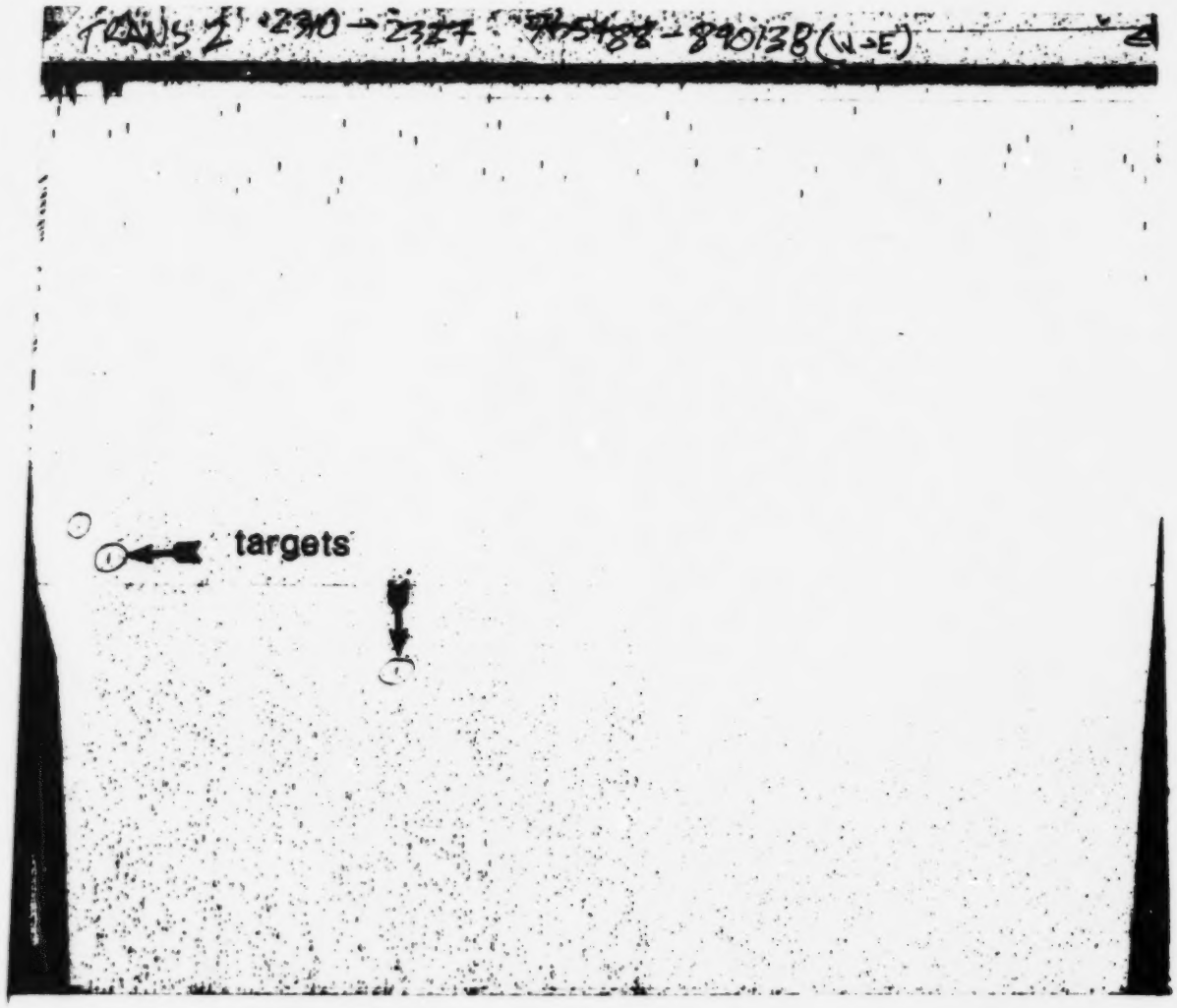



Fig. 9a. Reproduction of an echogram in which targets are masked by heavy electrical noise.

(ii) Move transducer, sounder and power supply to various locations within the boat to eliminate induction from the boat's power supply and cables.

(iii) Noise may result from Chaoborous larvae (Fig. 9b) or discontinuities. Currently no remedy exists for this problem and it is important to note that such a factor has been identified on a survey as the problem source. Recording whether the codend of the trawl net contains an abundance of fish larvae, or particular species of zooplankton after retrieval from a given depth stratum may confirm the source of fish target masking interference.

The technician or biologist conducting the acoustic survey should use his/her basic knowledge of the echo-sounder operation to solve problems which arise that are not outlined in the above guidelines.

## TRAWL SURVEYS

Trawl sampling supplements hydroacoustic surveys to accomplish two goals. First, data on the species and age composition of fish represented by acoustic targets are based on trawl catches. Second, trawl catches are used to assess relative abundance of fish within the 2-3 m layer immediately below the lake surface which the echo-sounder cannot sample. We use midwater trawls of various sizes but most commonly 2 m x 2 m x 7.5 m in width, depth and length respectively. The trawl is constructed of a graded series of meshes from mouth (5.0 cm stretch mesh) to codend (1.3 cm knotless nylon). A 350 um mesh plankton net is attached to the codend of the net to reduce loss of scales in fish collected. Towing speeds are maintained at 1.0-1.5 $m.sec^{-1}$. On each population survey we complete trawls at a series of depths to establish species and age composition of fish over their main depth range as indicated by the echo-sounder. General guidelines to be followed in completing trawl surveys are outlined below.

Additional trawl specifications may be required for certain lakes. If this is the case, a detailed set of instructions will be issued for the particular lake. The new set of instructions will override the following guidelines for the specified lake only. For an explanation of the techniques used for deployment of the midwater trawl refer to Gjernes (1979) and Robinson and Barraclough (1978).

(i) For lakes in which limnetic zone fish are virtually all juvenile sockeye of a single age group complete 4-9 trawls at various depth intervals as has been the practice in past years. One of these trawls must be a surface trawl.

(ii) For lakes with either mixed species composition or mixed age groups complete 4-9 trawls as outlined in step (i). Tally the total catch in this initial trawl set by depth strata, e.g.:

Fig. 9b. Reproduction of an echogram in which targets are masked by Chaoborous larvae.

| Stratum | Trawl catch as % |
|---|---|
| 0-3 m | 15 |
| 2-5 m | 30 |
| 5-10 m | 40 |
| 10-15 m | 10 |
| 20-30 m | 5 |

(iii) Identify each of the two depth strata (excluding the surface) in which the majority of sockeye and the majority of stickleback are taken. If sockeye are of mixed ages (as indicated by sizes) also identify the two strata which have the majority of each group. Do two additional replicate trawls within each of these strata.

(iv) Do two additional trawls at the lake surface.

(v) If the combined regular trawls and repetitive trawls do not identify the exact depth (within 2 meters) at which the two species or age groups separate, then carry out an additional trawl or trawls to precisely determine the depth at which separation does occur.

(vi) For each trawl, record: start time, duration, location of trawl in relation to transects (e.g. tran. 2->3,along 3) and distance log readings. (See form in Appendix 1.)

(vii) Just prior to executing a standard 15-min trawl be sure to note the log reading and place the distance log in water after letting out trawl line. Ensure that rotor movement on the distance log is not impeded by contact with the boat hull. Remove log and record readings just prior to bringing in the line.

(viii) When performing a surface trawl fasten two floats to the top trawl bar and deploy 50 m of line. Maintain a sinusoidal pattern with the trawl boat, this will insure the trawl net is kept clear of the boat wake and net efficiency is not reduced.

(ix) For trawls of up to 5 m in depth the same technique as outlined in step (viii) should be followed. Adjust the length of line on the floats to obtain the desired trawl depth.

(x) For trawls of greater than 5 m in depth a warp angle of 17° must be maintained. Check the angle frequently during the trawl. To select the correct warp length for the desired trawl depth refer to Fig. 10. This relationship is unique for each boat type so be sure to use the correct chart.

(xi) Any plankton samples (usually Chaoborus sp. or Neomysis sp.) should be retained and preserved with the fish from the particular trawl. These samples are useful for short-term and possibly as a long-term index of abundance. Knowledge of the type and quantity of zooplankton present within a depth stratum aids in interpretion of echogram targets.

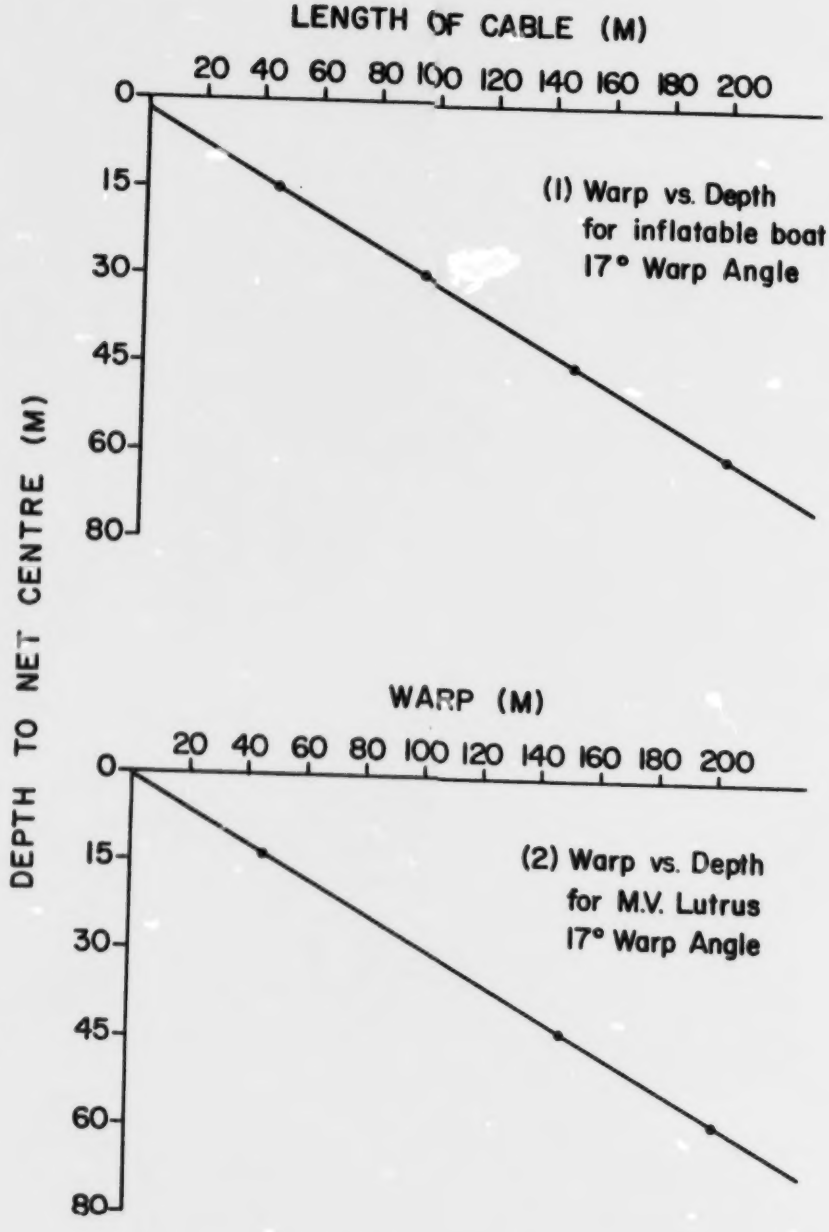



Fig. 10. Relationships between trawl-net depth and length of cable maintained at an angle of 17° to horizontal when deployed from a small (4 m) inflatable boat (9a) and the larger M.V. LUTRUS (9b).

(xii) Label trawls from trawl no. 1 through to the number of trawls performed on a lake. Use the waterproof labels supplied by the Lake Enrichment Program (Fig. 11). Do not repeat trawl number. For example if a lake is surveyed over two nights and trawls no. 1 through no. 4 are performed on the first night, continue the numbering on the second night with trawl no. 5 (not trawl no. 1).

(xiii) If no fish are caught in a trawl, record the trawl information and give the trawl a trawl number. Preserve any accumulations of zooplankton from the codend. A simple, plastic kitchen strainer may be useful for catching this material for transfer. Record in the field notes "no fish caught" and use the next trawl number for the next trawl.

(xiv) In the event that large catches of fish are obtained in 15-min trawls, randomly subsample 100 fish from each trawl catch to be retained for laboratory processing. Tally and record the entire contents of each trawl catch of greater than 100 fish. Discard fish not required for laboratory processing. Do not reduce trawl duration.

## HYDROACOUSTIC AND TRAWL SURVEY DOCUMENTATION

### Field Notes

Field notes are an important document in the data acquisition process. With regard to juvenile acoustic surveys the field notes are the definitive document in the verification of the collected data. It is therefore imperative that all information is recorded accurately on waterproof paper. Writing directly onto the echogram without producing field notes is not sufficient. Due to the nature of sounder paper the surface coating can be easily damaged thus losing the information recorded on it. In order to maintain consistency among field notes recorded by different personnel the following set of guidelines should be adhered to:

(i) Record lake name, date of survey, field crew personnel, type of echo-sounder used and trawl net size (i.e. mouth dimensions, mesh and codend type).

(ii) Record weather conditions in the following format.

Rain - record as rain, no rain, showers.

Cloud cover - record as percent cover (e.g. 50% cloud cover).

Moon - record as present or absent, record rise/set time only if it occurs during the survey, if moon is present record the phase.

Wind - record as light, moderate, heavy, or gusty.

Water condition - record as calm, rippled, rough. If conditions change during the survey record the change; always record surface temperature!

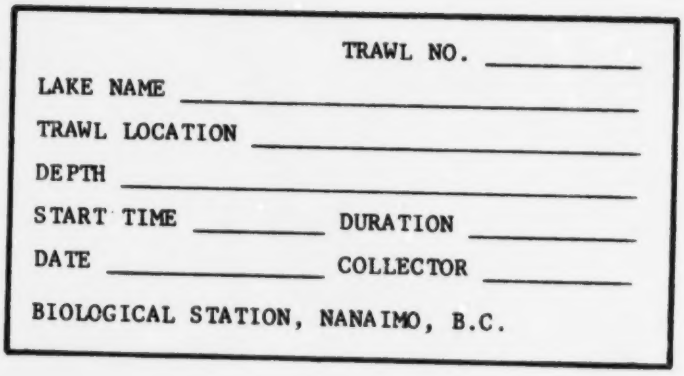



Fig. 11. Reproduction of a trawl-sample label.

(iii) Record date and time accurately. Use the 24:00 clock. Record time in current time, if the survey is conducted during P.S.T. then record time in Pacific Standard Time. If the survey is conducted during P.D.T. then record time in Pacific Daylight Time.

## ZOOPLANKTON SAMPLING

Zooplankton samples provide us with much information about the food supply of juvenile sockeye and limnetic stickleback. From the samples we obtain: an index of the more common species potentially available to the limnetic fish populations; some measure of the abundance and size distribution of prey; and an index of the scope of the lake to support fish and fish growth. Most of the zooplankton sampling to date has been done under the limnology contract. However, there are definite advantages to having the people who are conducting the juvenile sockeye surveys take zooplankton samples as well. First, zooplankton samples taken within 12 hours (usually less) of the trawl samples will facilitate comparisons between limnetic fish gut contents and the spectrum of prey available in the limnetic zone. Second, because of the new strategy of sampling small sockeye lakes not visited by the limnology crew, we can get information regarding the zooplankton communities in these lakes that we would not normally obtain.

Historically, the zooplankton have been sampled with a 100 um, 0.25 $m^2$ Scientific Committee on Oceanic Research (S.C.O.R.) net. For the purposes of continuity this gear will continue to be used. The following procedures should be observed when making a plankton haul:

(a) Sampling site should be in mid-lake and in a main basin.

(b) Samples should be collected during the day (perhaps when the transect marker lights are deployed would be a good time).

(c) Attach the bucket, the weight and then take flowmeter reading(s) (there may be more than one flowmeter attached to the net).

(d) Make certain the flowmeter has no air bubbles in it. If so, remove the screw and fill the flowmeter with water.

(e) Immerse the net and make certain that neither the net nor the cup have any air trapped in them.

(f) Use the heaviest weight that is readily manageable to drop the net quickly to depth. (The depth is predetermined in consultation with the scientific authority.) Rapid net descent allows the pin to engage the flowmeter rotor, preventing it from turning. Observe the "inside" rotor to ensure that it is indeed not turning. Some adjustments of the line from the bridle to the pin may be necessary.

(f) The net is then pulled up as smoothly and quickly as possible (about 0.5 m/sec.).

(g) When the net reaches the surface, grab the flowmeter to stop the rotor turning and take a reading.

(h) Lift the second net hoop clear of the water and rinse the contents of the conical portion of the net into the codend by "dunking" and gradually lifting the net out of the water until the codend is reached. Note: be sure that enough water is filtered out of the net so the sample fits into the bucket, otherwise part of the sample will spill out when the bucket is removed. This problem usually occurs during summer months. More water can be extracted from the sample in the net by holding the codend upright and gently patting the wire mesh on the side of the bucket.

(i) Detach the plankton bucket and remove as much water as possible from it (see g) before transferring the sample to a jar by immersing the empty bucket in water until the wire mesh is covered. This allows water to filter through the wire mesh into the bucket. Rinse out the bucket and transfer this water to the sample jar with the rest of the sample. Add the label and fill each jar completely with water. The jars are supplied and should already contain a concentrated (37%), borax-buffered, sugar-formaldehyde solution that will yield 4% formalin when the jar is filled with water.

The label should contain the following information: date, lake name, station number (location usually predetermined in consultation with Scientific authority), net used (usually SCOR), flowmeter(s) start and finish (usually inside, possibly outside as well), type and depth of haul in meters (usually a vertical haul, VH from 25 or 50 meters).

## SUMMARY TRIP REPORTS

Immediately after completion of a field survey a summary trip report is required in addition to labelled echograms, copies of original field notes, photographs, slides, preserved samples, etc., . . . . See Appendix 1 of this document for the formats to be followed in reporting field survey results. Field notes should generally be rewritten to make them more legible and expanded upon to make them more meaningful. Be receptive to recording general observations of biological events or site characteristics that might be of interest to program personnel. Examples include notes on: unusual water conditions (e.g. algal blooms, high turbidity, flood levels); times, numbers and species of adult salmonids observed in various locations, identification of good sites for smolt or adult counting weir placement; observations of the distribution and abundance of potential predators on sockeye, etc.

If problems occur during a survey make note of them. For example if mechanical difficulties occur during the survey, or if a survey is interrupted for a period of time, record the nature of the problems or delays. In the event that damaged or improperly working equipment is

returned, a written explanation describing the damage or problem must be submitted to the equipment technician within the Fish Ecology Unit. Suggestions for site improvements, sampling procedure alterations and reminders for later trips should also be noted here.

Finally, it is important for contract personnel to remember that they will often constitute the "arms, ears and eyes" of the Fish Ecology Unit in the field. In many cases a contract crew alone will carry out surveys to new lakes and consequently their reports will represent our only source of site-specific background necessary to shape decisions on future studies.

## ACKNOWLEDGMENTS

This field guidelines report has developed as an outcome of a requirement to conduct many assessment activities of the Lake Enrichment Program through the process of contracting-out work to a variety of environmental consulting firms. Accordingly, we extend our thanks to personnel of LGL Environmental Research Associates (Sidney, B.C.), International Environmental Consultants (Richmond, B.C.), J. C. Lee and Associates (Nanaimo, B.C.) and MacLaren Plansearch Corporation (Vancouver, B.C.) who have been involved in various phases of our work over the past six years. In particular, Mr. Kent Wiley of MacLaren Plansearch deserves special recognition for his interest and contributions to the continuity of our field program as well as for helpful criticism of the manuscript. The authors also wish to thank Dr. John Stockner, Greg Steer and Ron Traber for critically reviewing the report. Thanks are extended to Ms. Terry Beg for typing and to Sherry Greenham of Malaspina College (Nanaimo, B.C.) for drafting the figures.

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APPENDIX 1. Summary Trip Reports.

Lake Name  Date(s)  Field Crew: names

Survey Type:

| | |
|---|---|
| Smolt trapping | x |
| Stickleback trapping | x |
| Acoustic and trawl survey | x |
| Zooplankton sampling | x |
| Other (specify) | x |

Gear Employed by Survey Type — Separate narratives may be required for each type of survey and comments may have to be modified on a lake-by-lake basis, e.g., smolt trapping: 2 m x 2 m trawl net supplemented by a 20 m, 6 mm stretch mesh, nylon wing. 100% of stream flow sampled.

Survey-site Description — If appropriate (i.e. separate narratives required for smolt trapping, stickleback trapping, zooplankton sampling).

Survey Results — Follow a common format for summarizing results for each type of survey. A sample form is attached to indicate the entry format for results from (a) acoustic, (b) trawl, (c) Gee-trap, (d) smolt-trap, or (e) zooplankton net-haul surveys.

Qualifying Comments: — Include weather conditions, water conditions and all comments from field notes here.

Add any other pertinent comments or suggestions here, e.g. survey ran smoothly, plane beaching site needs clearing, caught net in prop.: 40 min delay between transects 1 and 2 on trawl survey; 2000 adult sockeye observed schooled off Clemens Creek, etc. . .

APPENDIX 1 (cont'd)

| Date | Location no. | Sample no. | Set depth[2] (m) | Sampling time[3] | | Catch[4] | | | | Heading[5] | Gain[5] | Flow meter log[6] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Start | Finish | Sock | Stick | Coho | Other (specify) | | | Start | Finish |
| | | | | | | (a) Acoustic | | | | | | | |
| July 23 | T-8 | - | - | 2216 | 2227 | - | - | - | - | 231 | 10 | 87823 | 73400 |
| | T-7 | - | - | 2250 | 2310 | - | - | - | - | 232 | 10 | 61300 | 59234 |
| | T-6 | - | - | 2330 | 2350 | - | - | - | - | 231 | 10 | 59234 | 53232 |
| 24 | T-5 | - | - | 0015 | 0030 | - | - | - | - | 229 | 10 | 44777 | 39200 |
| 0-50 m used on all transects | | | | | | | | | | | | | |
| | | | | | | (b) Trawl | | | | | | | |
| July 25 | 1-2 | 1 | 0 | 2230 | 2245 | 50 | 0 | 0 | 1 lam. | - | - | 73400 | 71922 |
| | 4-3 | 2 | 10 | 2354 | 2409 | 100 | 0 | 0 | 0 | - | - | 53230 | 44588 |
| | 4-3 | 3 | 50 | 2415 | 2430 | 0 | 0 | 0 | 0 | - | - | 33880 | 26300 |
| | | | | | | (c) Gee-trap | | | | | | | |
| Aug. 5 | G-1 | 1 | .25 | 1400 | 1900 | 0 | 150 | 5 | 5 sclp., 15 pmth. | - | - | - | - |
| | | 10 | 1.50 | 1415 | 1915 | 1 | 10 | 0 | 1 sclp. | - | - | - | - |
| | | | | | | (d) Smolt-trap | | | | | | | |
| May 5 | S-1 | 1 | .50 | 2000 | 2020 | 10 | 1 | 2 | 0 | - | - | - | - |
| | | 2 | .25 | 2040 | 2100 | 2 | 0 | 0 | 0 | - | - | - | - |
| | | 3 | .50 | 2100 | 2120 | 10 | 0 | 1 | 0 | - | - | - | - |
| | | 4 | .50 | 2130 | 2200 | 20 | 0 | 1 | 1 lam. | - | - | - | - |
| | | 5 | .50 | 2200 | 2430 | 5 | 1 | 0 | 0 | - | - | - | - |
| | | 6 | .50 | 2430 | 0800 | 60 | 3 | 10 | 0 | - | - | - | - |
| | | | | | | (e) Zooplankton net-hauls | | | | | | | |
| Sept. 20 | Z-1 | 1 | 50 | 1300 | 1305 | - | - | - | - | - | - | 65200 | 63400 |

FOOTNOTES TO APPENDIX 1.

[1]Heading alternatives for survey type include: smolt trapping, Gee-trap, trawl, acoustic or zooplankton net-hauls. Location numbers refer to transect locations, or station locations for various types of surveys. Sample numbers are to be applied to individual trawl catches, trap samples, time intervals from smolt sampling or zooplankton net-haul samples.

[2]Set-depth in meters is recorded for smolt trapping, Gee-traps, trawling or zooplankton net-hauls.

[3]Start and finish times include only the interval during which gear is actively sampling, i.e. do not include time for gear-deployment or retrieval.

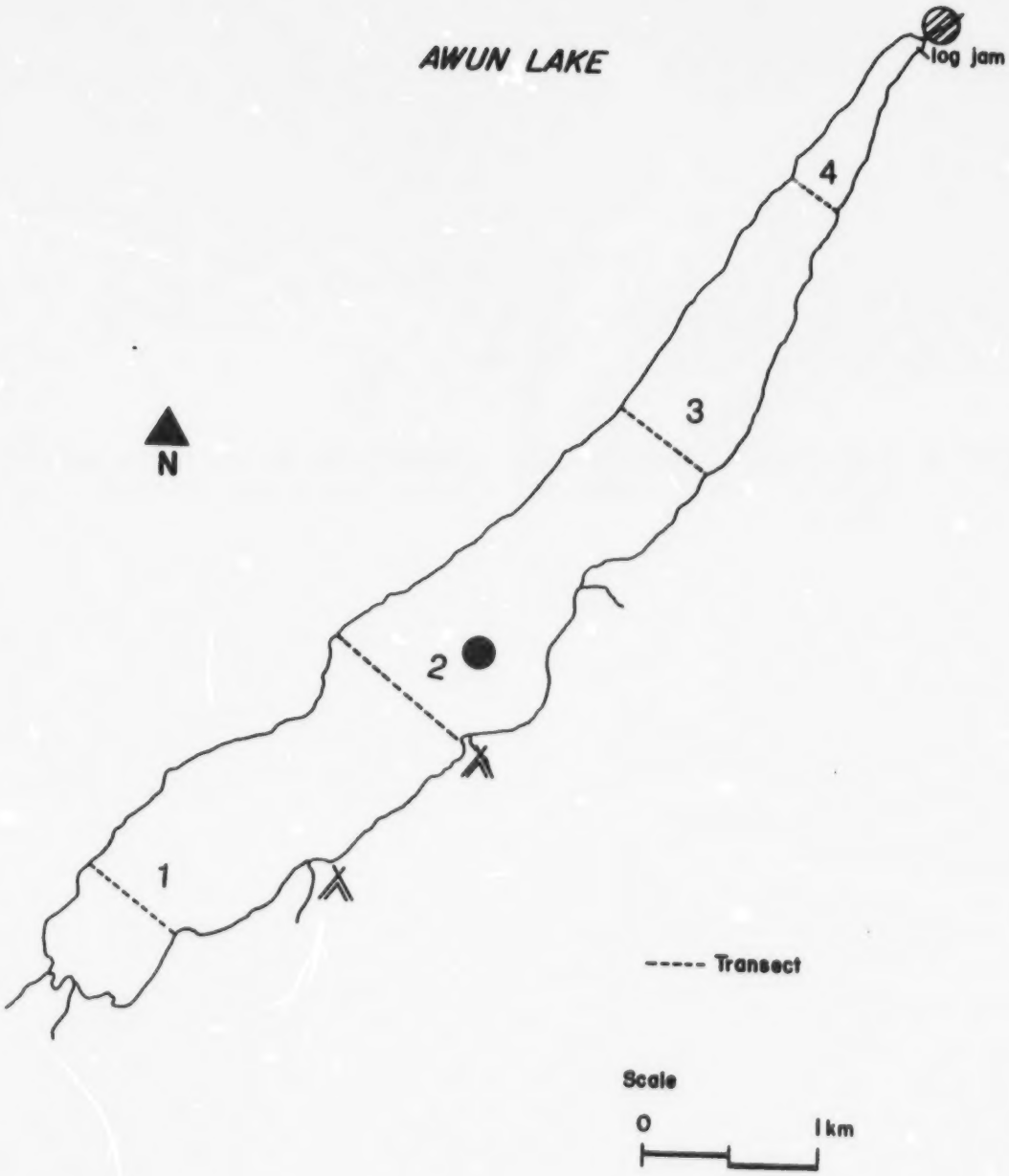
[4]Where appropriate record exact catch and include entries of no catch if this occurs.

[5]Recorded only for acoustic transect surveys.

[6]Record required only for acoustic transect, trawl and zooplankton sampling.

APPENDIX 2. Lake specific locations of: transects for hydroacoustic and midwater trawl surveys, and offshore zooplankton net-haul stations.

APPENDIX 2 (cont'd)



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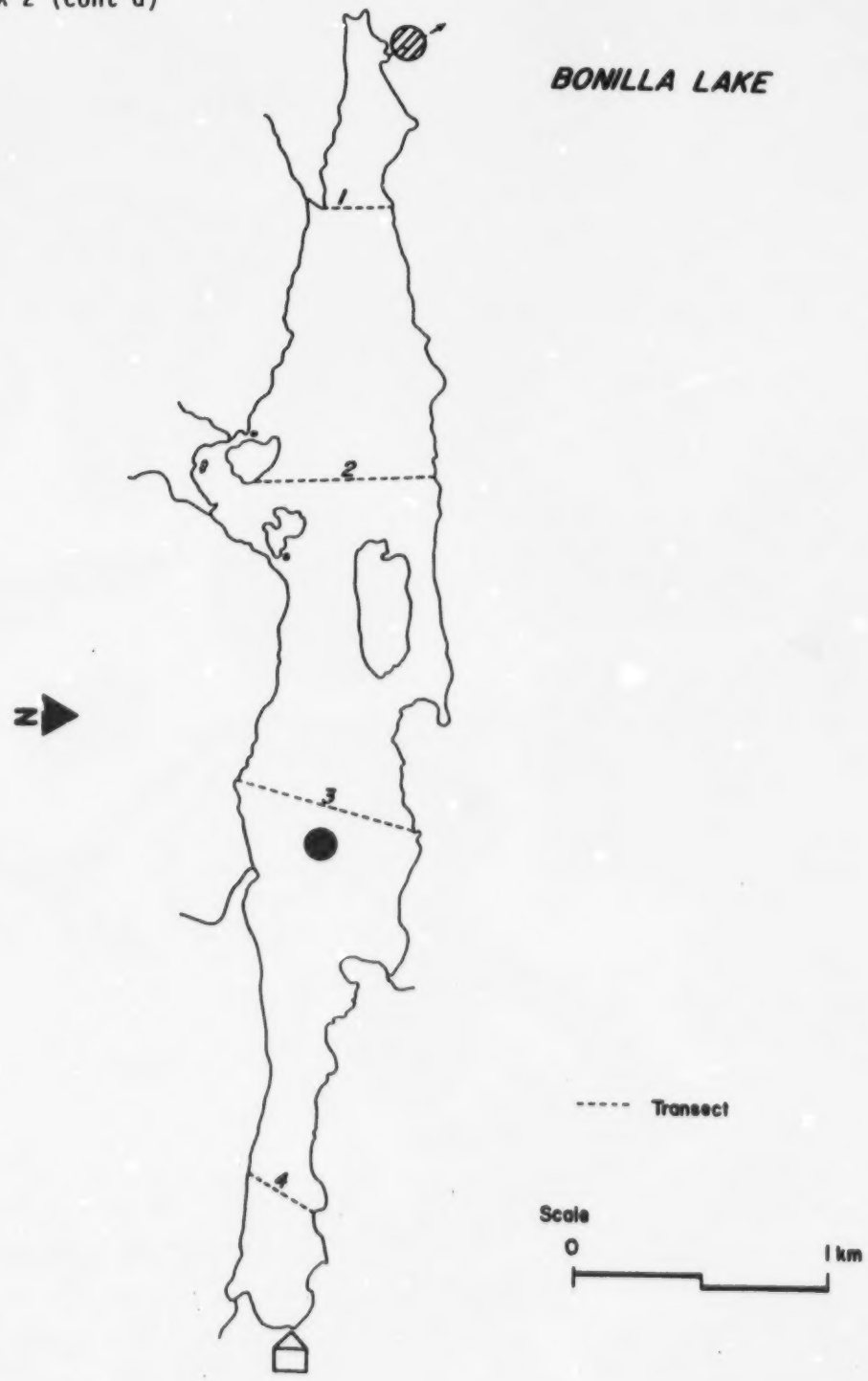

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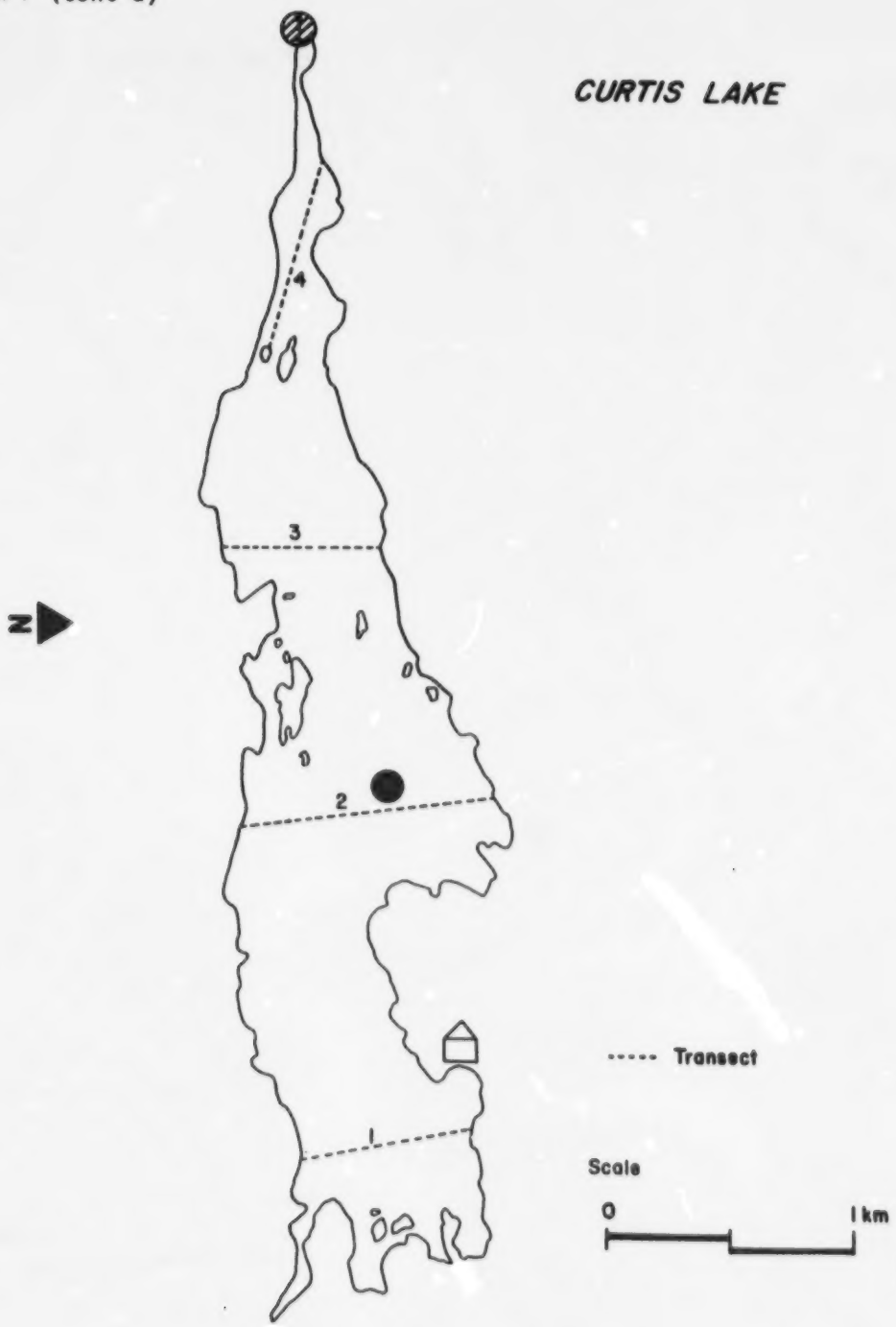

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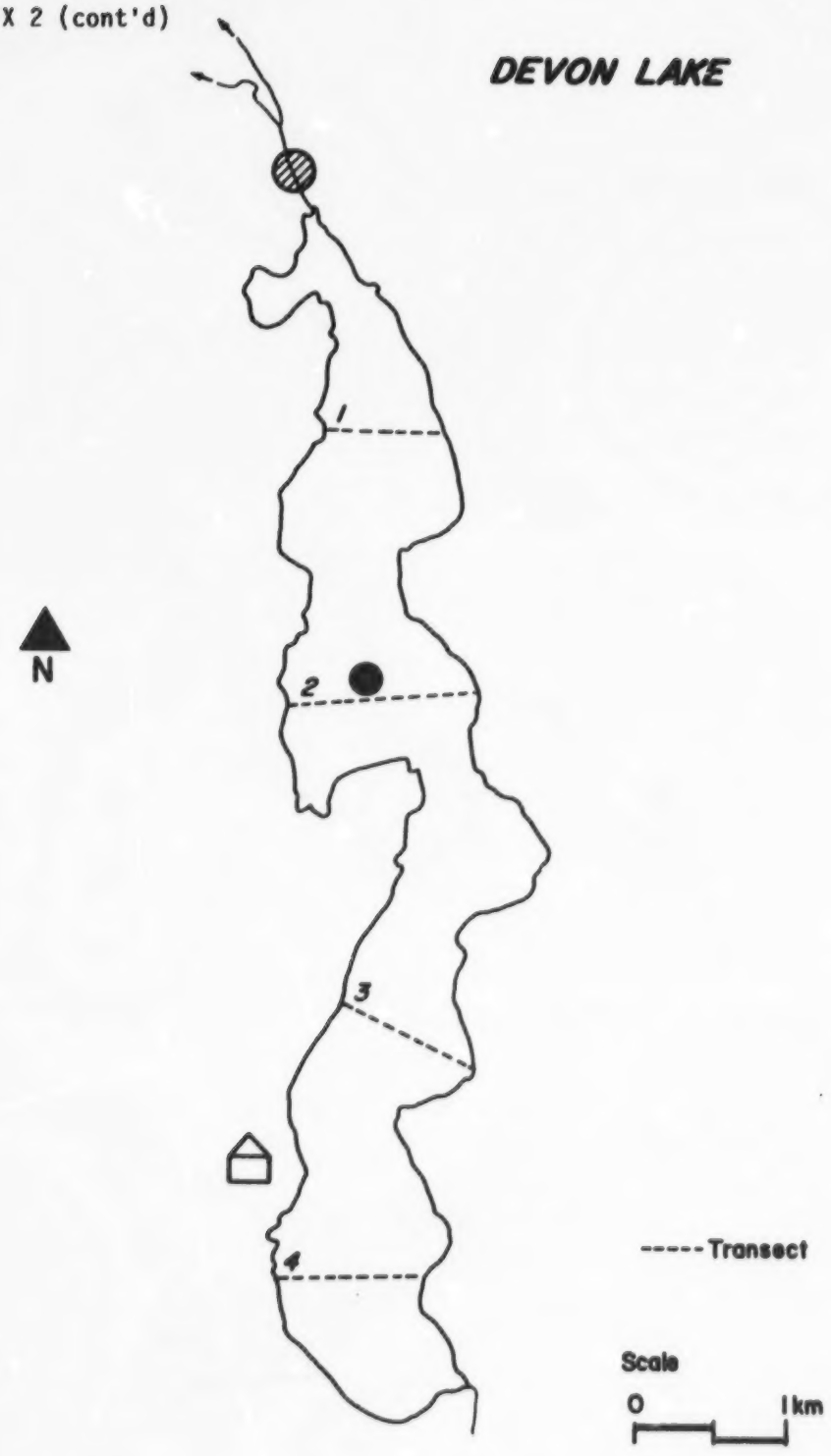

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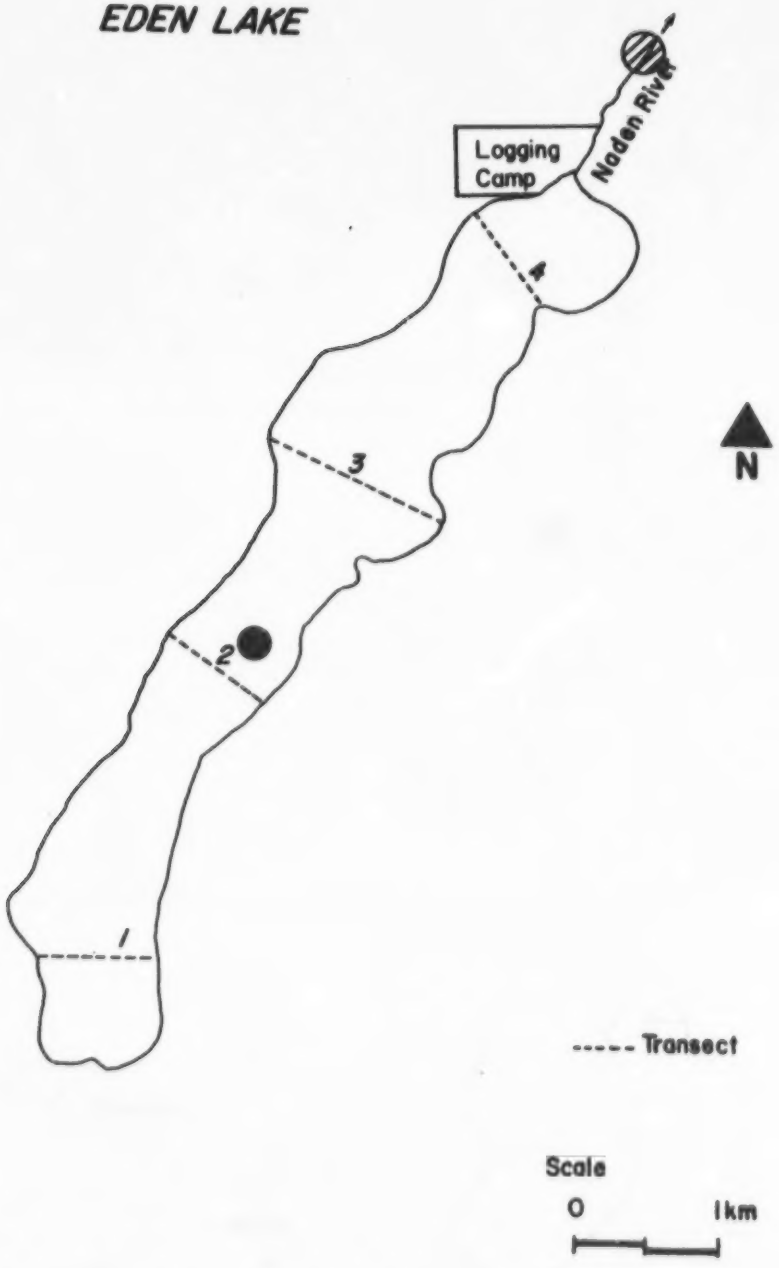

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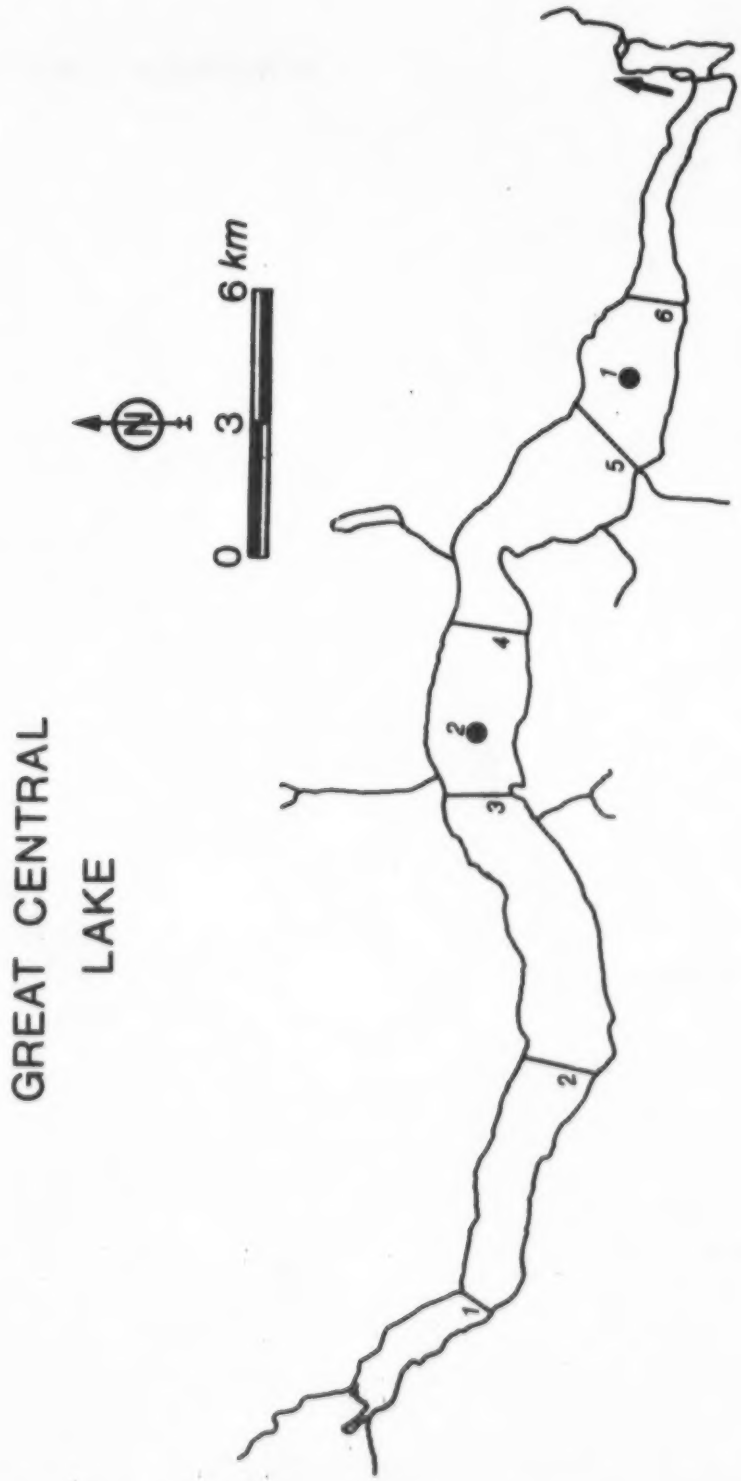

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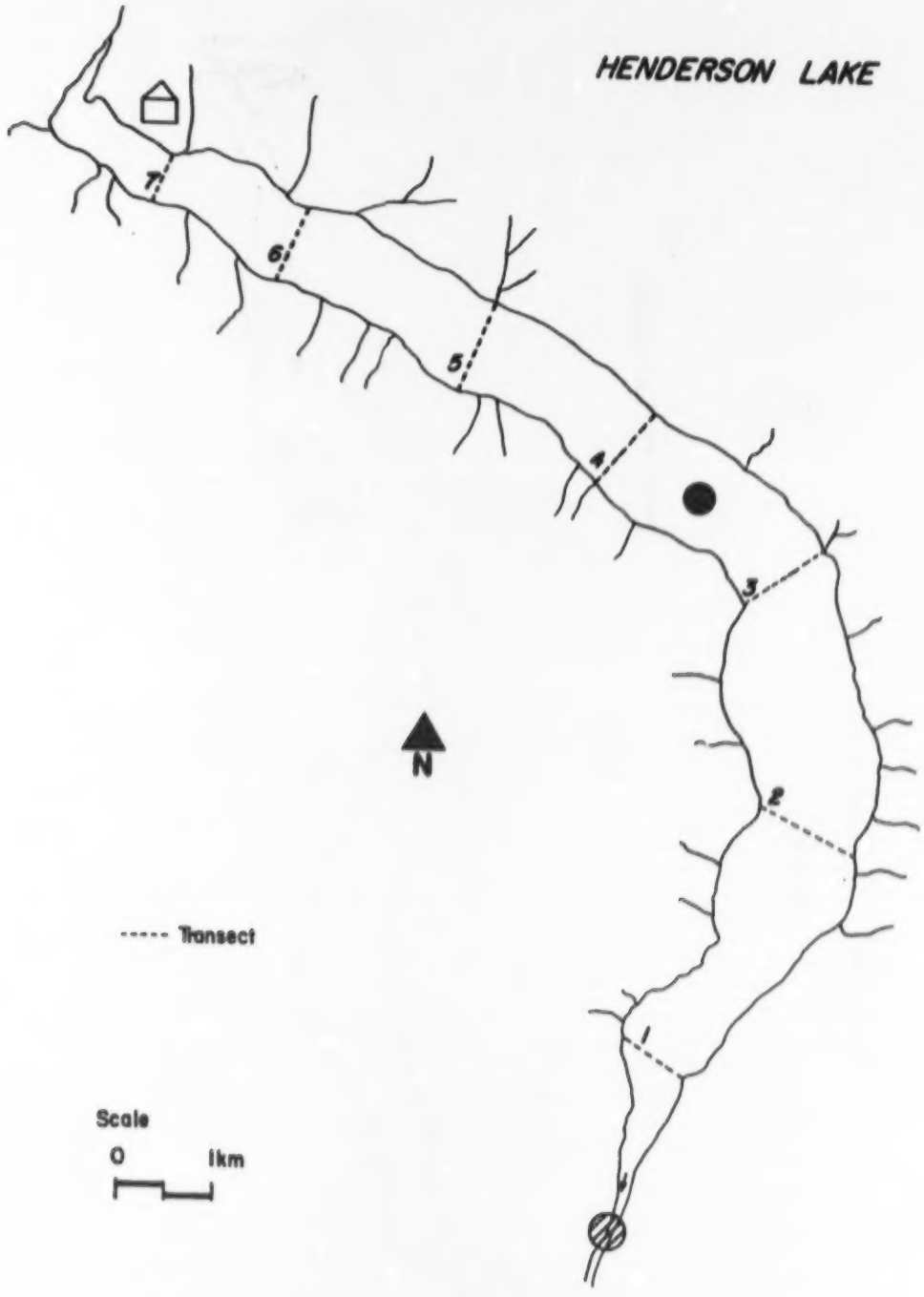

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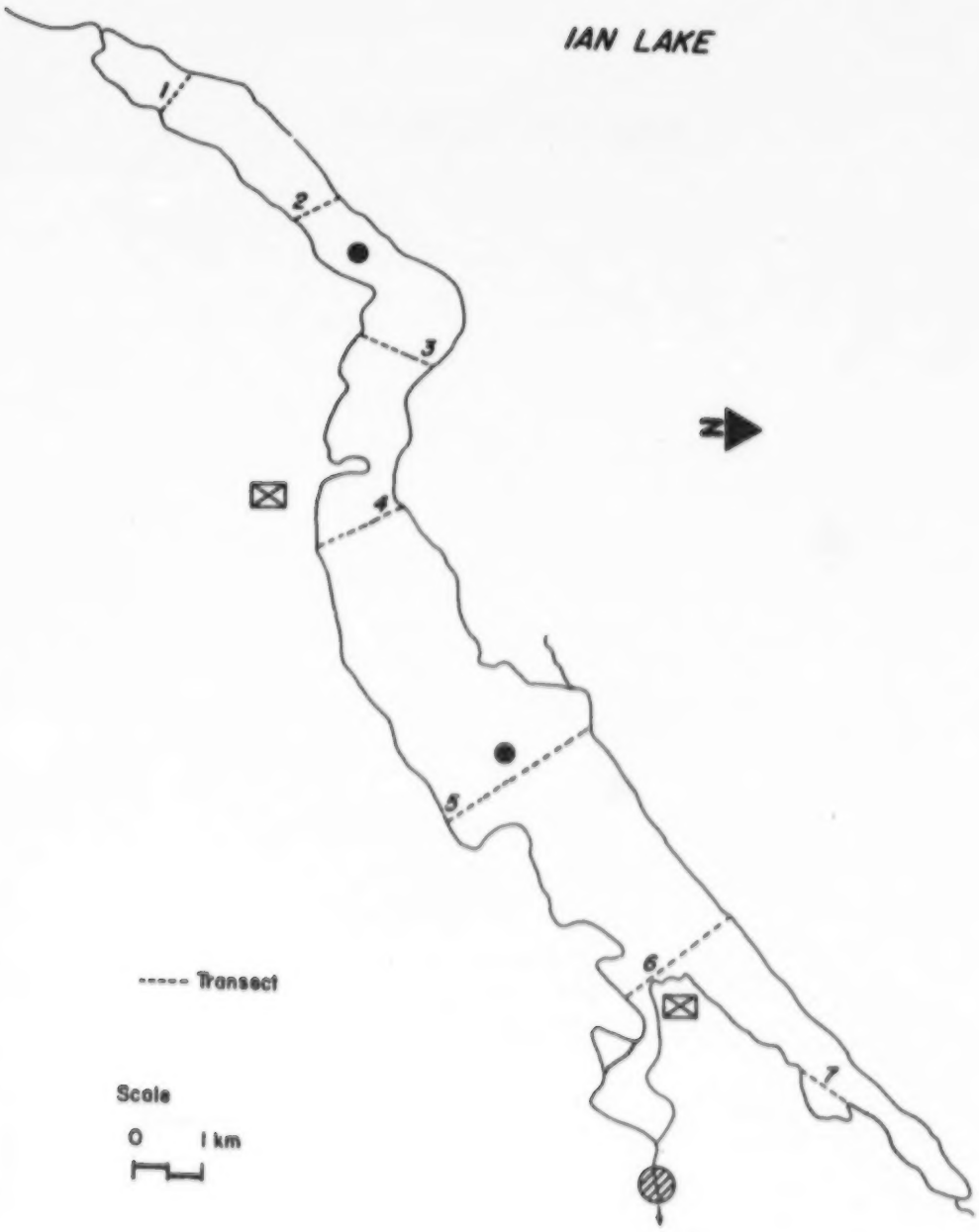

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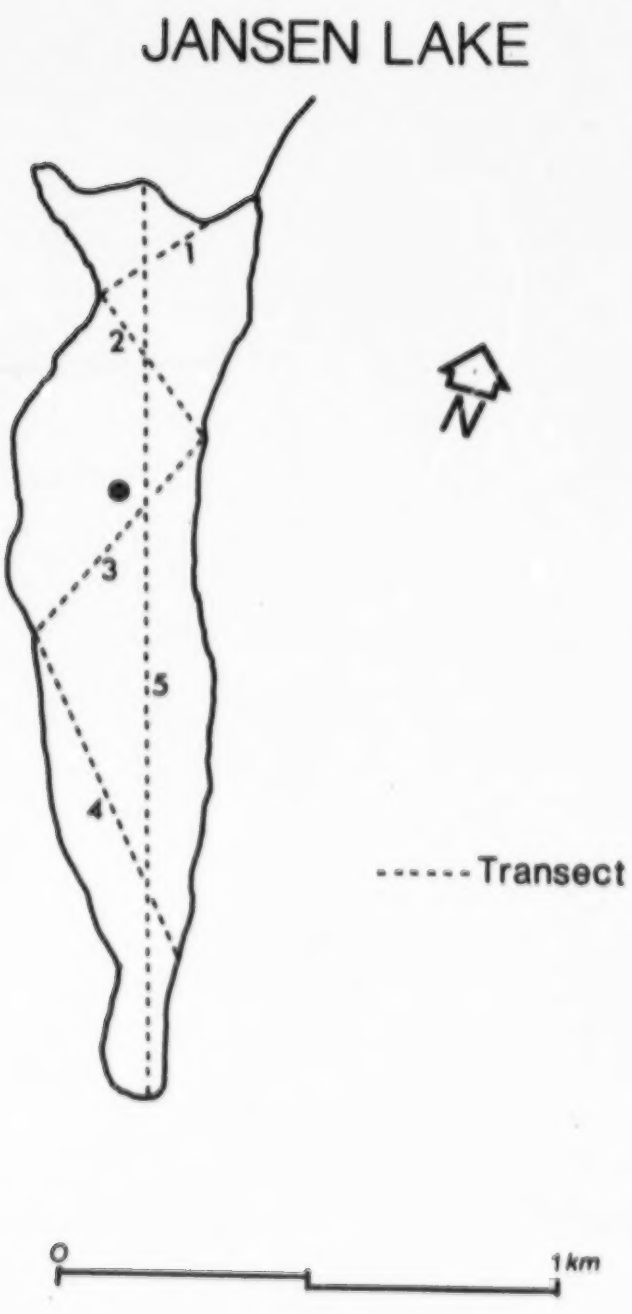

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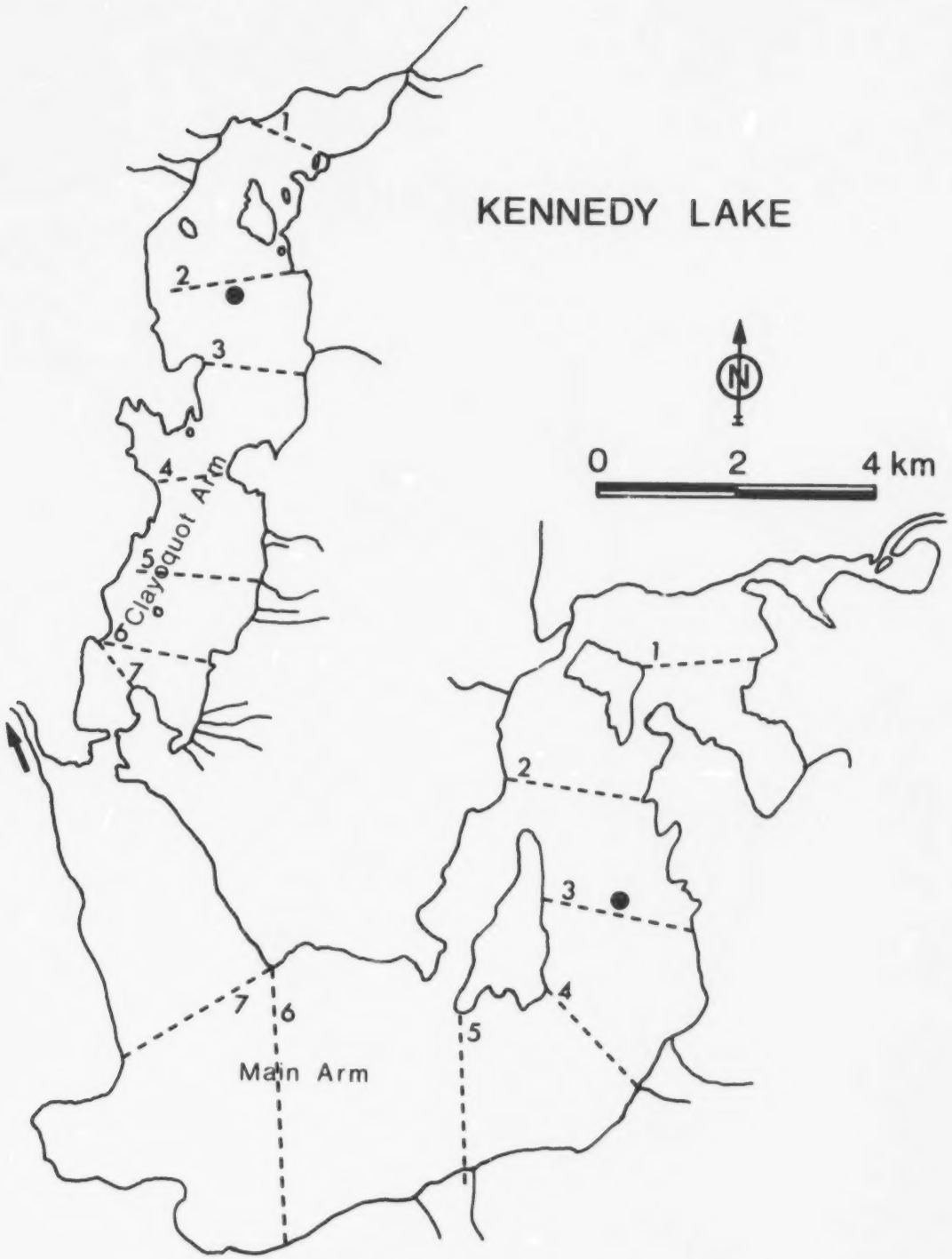

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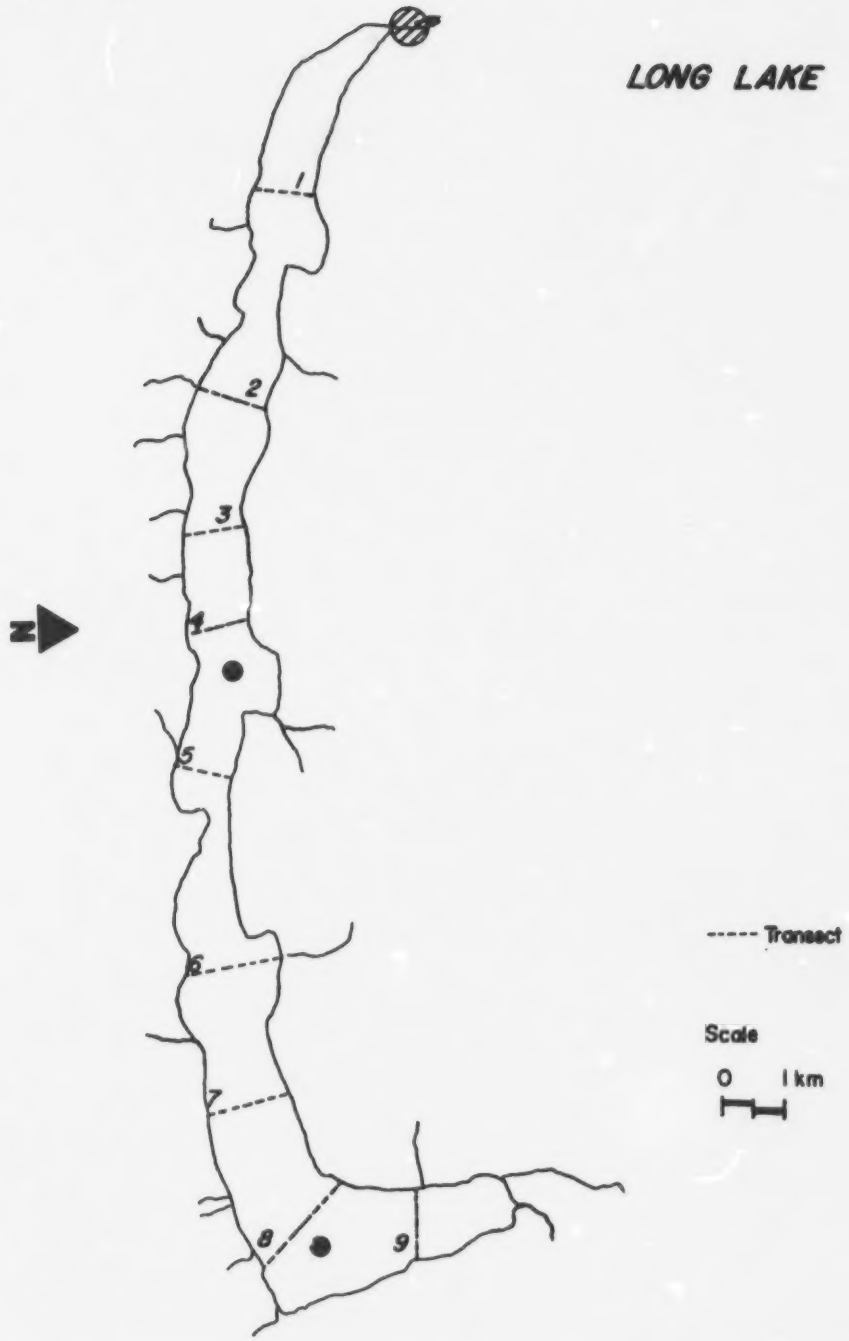

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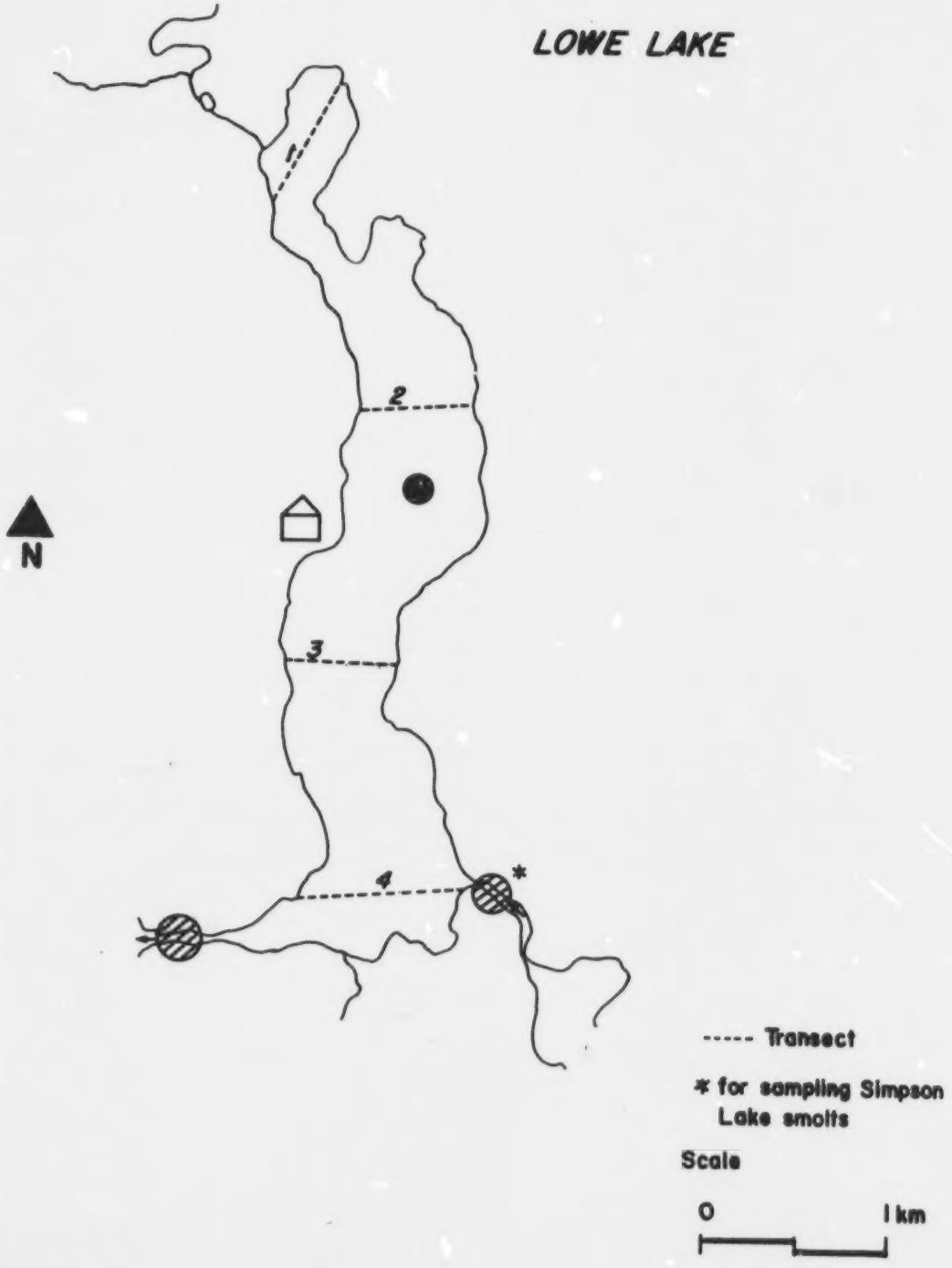

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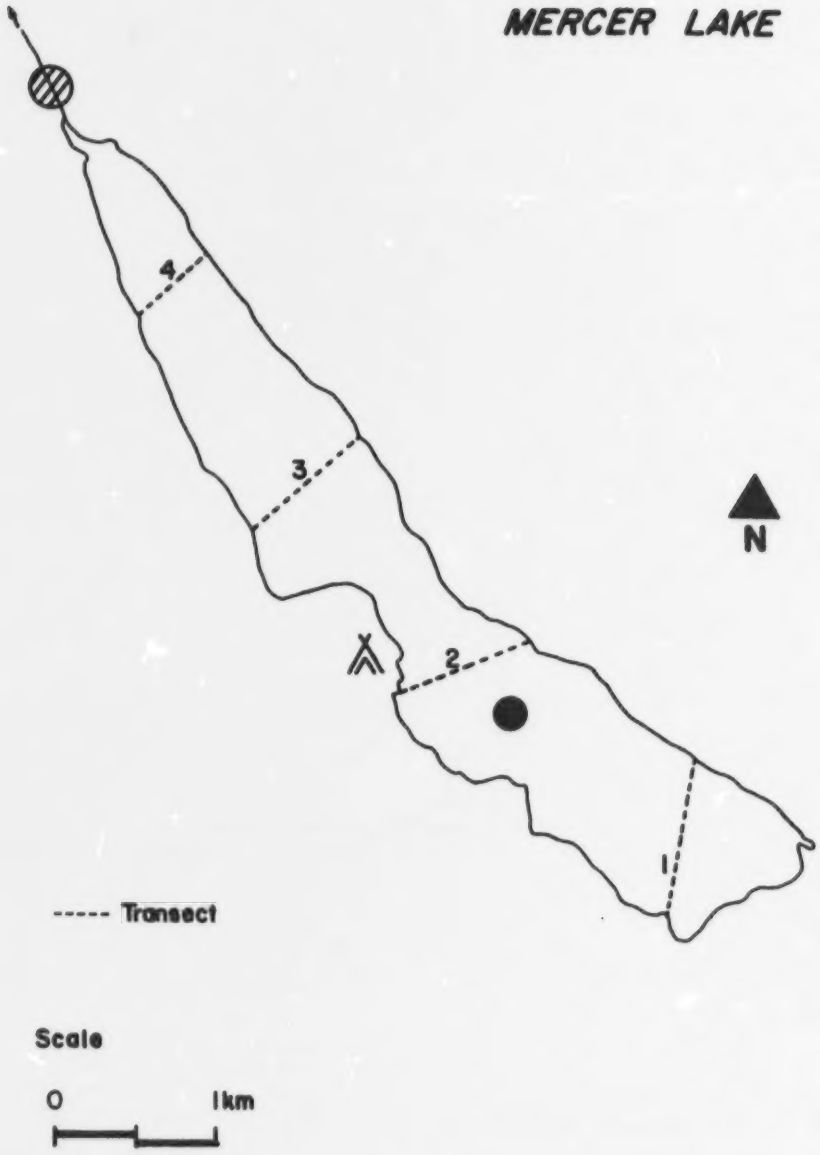

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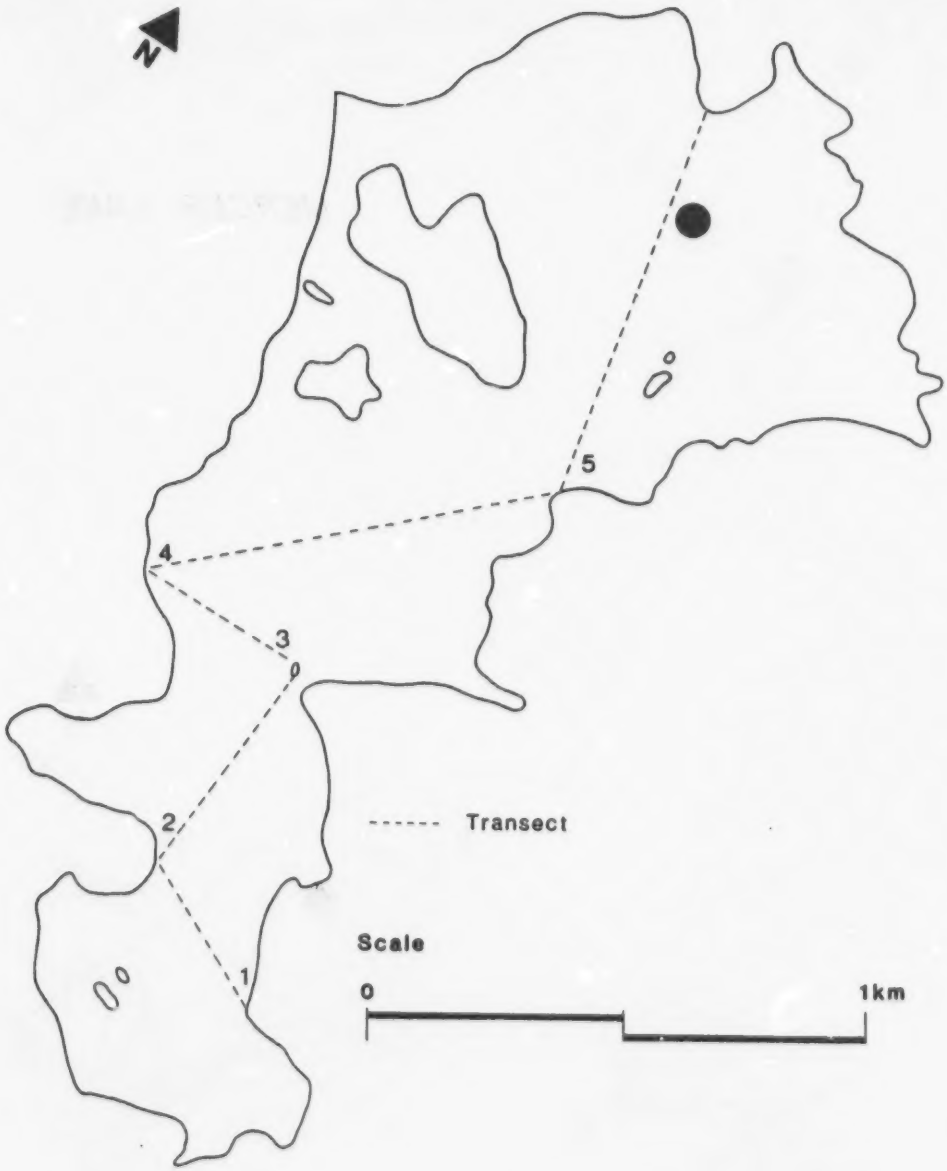

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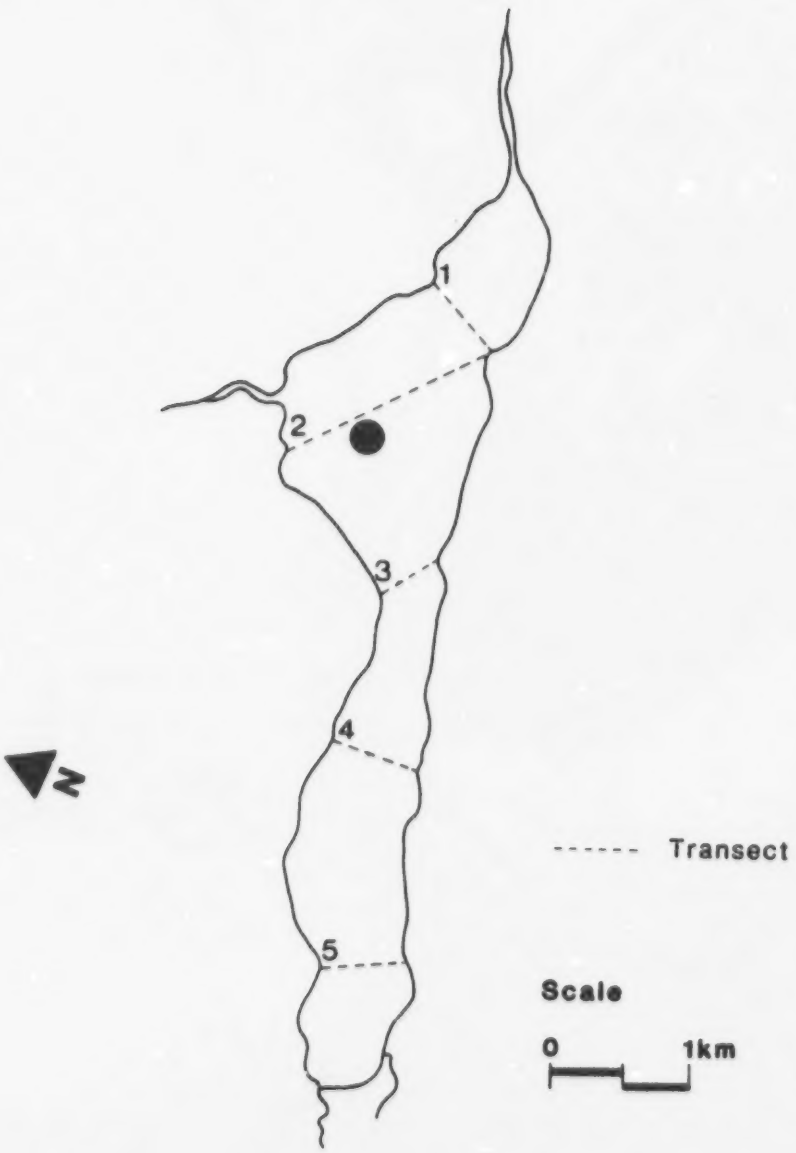

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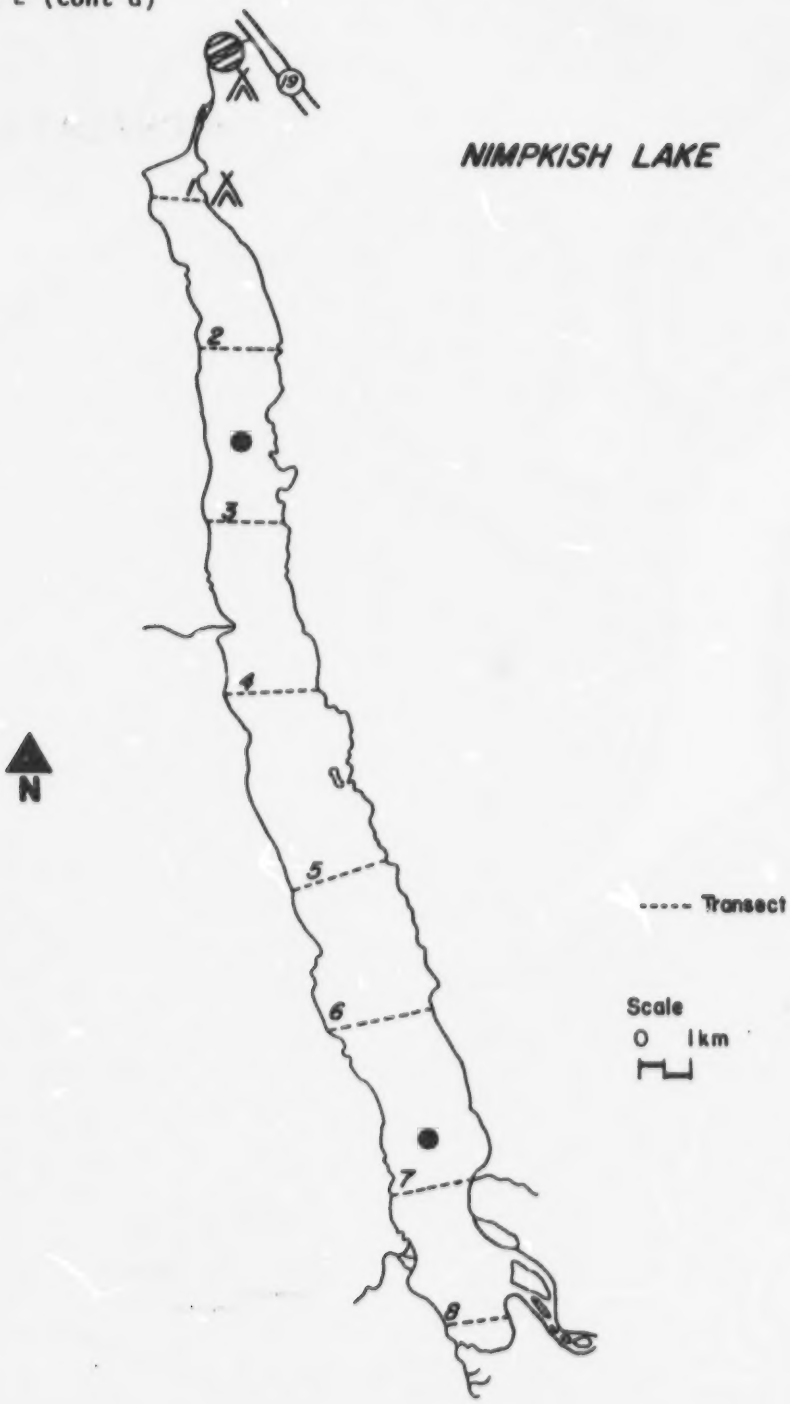

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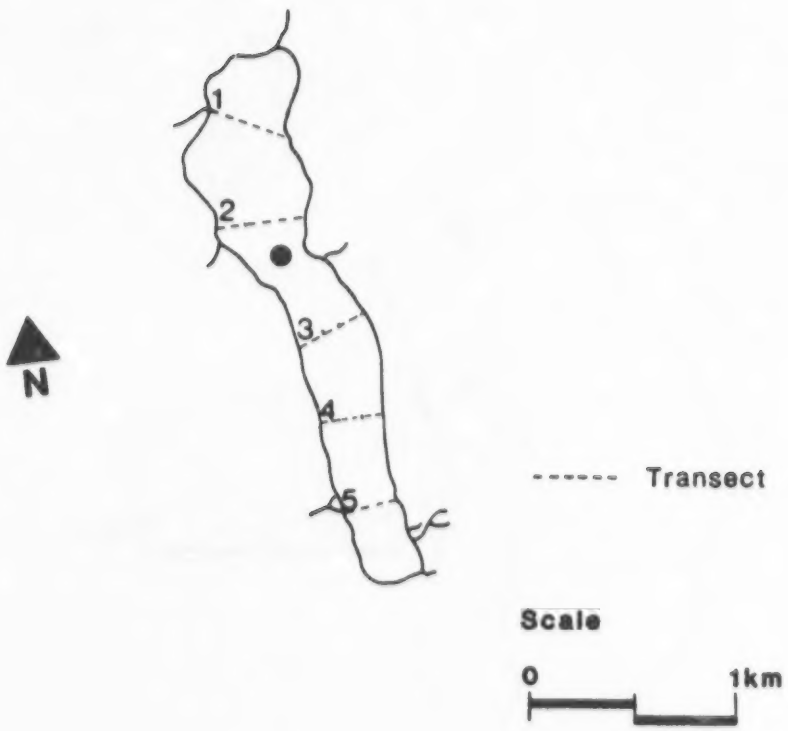

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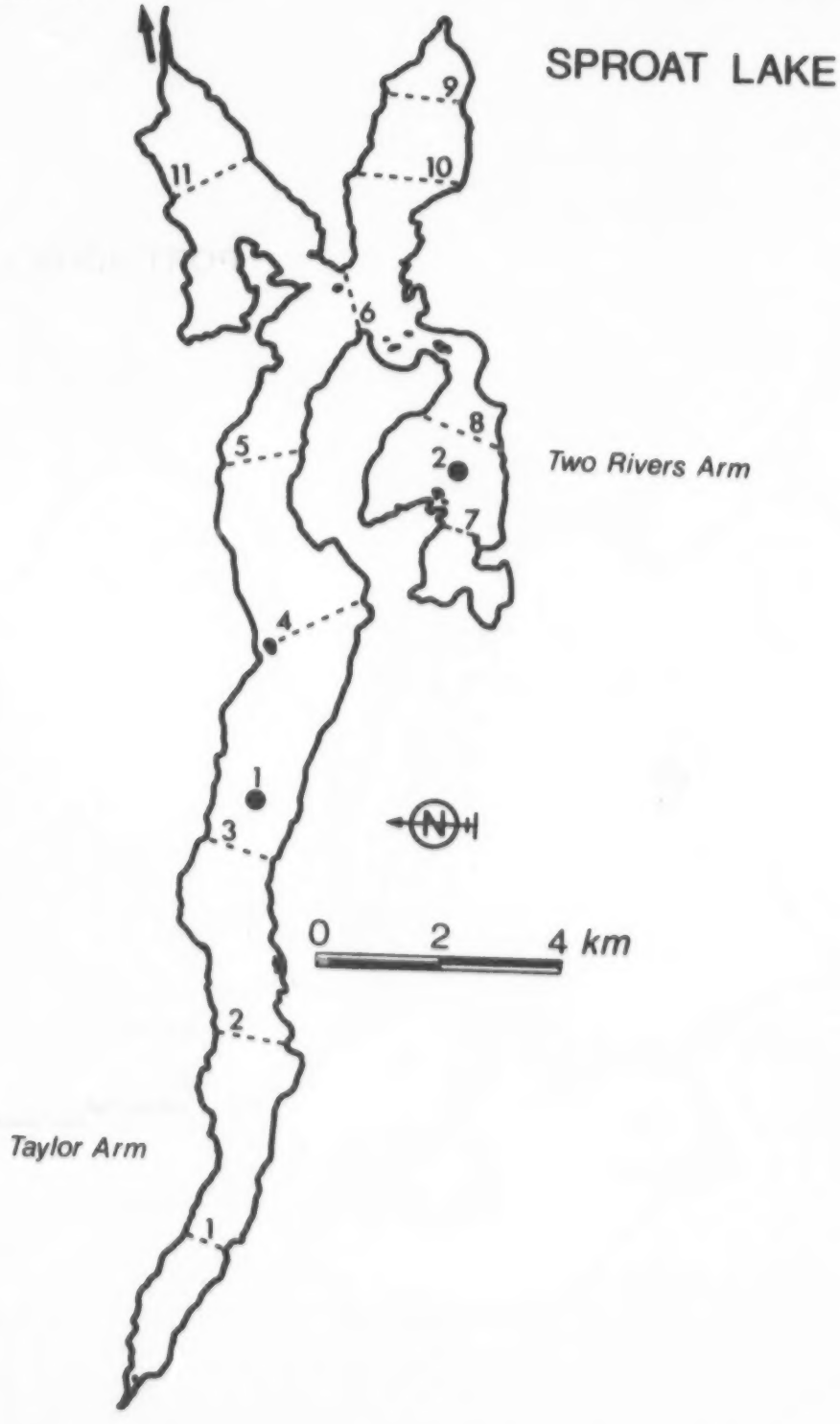

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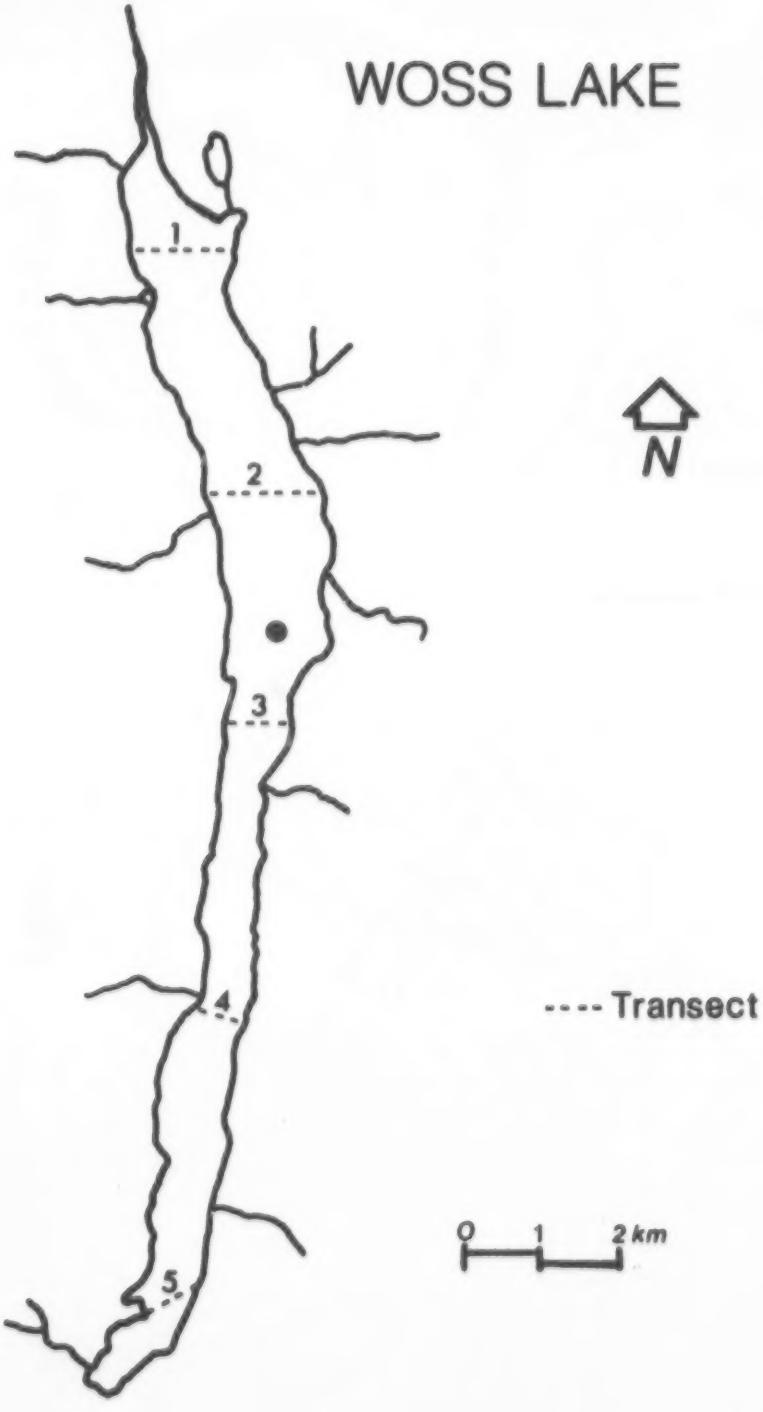

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